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VOLUME XIV
1917

PUBLISHERS
AMERICAN MEDICAL ASSOCIATION
CHICAGO, ILL.

VOLUME 14 NUMBER 1

JUL 5 1917
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PUBLISHED BY
AMERICAN MEDICAL ASSOCIATION
CHICAGO, ILL.

Entered as Second-Class Matter, January 4, 1911, at the Post-Office at Chicago, Illinois, Under Act of Congress of March 3, 1879

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American Journal of Diseases of Children

Vol. 14 JULY, 1917 No. 1

PROTECTION OF CHILD LIFE DURING THE WAR

The General Medical Board of the Advisory Commission of the Council of National Defense early this spring sent out letters to various organizations, requesting the latter to make recommendations indicating in what way they could be of service in the present national crisis. In accordance with this request, representatives of various organizations interested in maternal and child welfare, met in committee at Washington in June, formulated the recommendations given below, and sent them to the General Medical Board.

A glance at the list of societies represented on this committee shows the widespread nature and distribution of the associations interested in infant and child welfare. On the committee are represented not only medical societies and specialists, but also public health and social organizations dealing with these problems.

The chief object of the committee, of course, was to make on a broad, comprehensive scale, recommendations and suggestions looking toward the protection and preservation of the child life of the nation during the war. The recommendations obviously must be of a general nature. The practical application of these recommendations must be left to the individual community, according to the peculiar local conditions of that community.

The report gives evidence of so much thought and expert knowledge, of such care in its preparation, that we believe it will be of universal interest to physicians interested in work among infants and children.—F. S. C.

WASHINGTON, D. C., June 15, 1917.

At the request of the General Medical Board of the Advisory Commission of the Council of National Defense the following report of measures recommended for the protection of children in war time is submitted:

1. We urge the Council of National Defense to direct that, so far as practicable, physicians teaching obstetrics and pediatrics and those devoting themselves exclusively to problems of maternity and of infant and child welfare, continue in such service either at home or abroad.

2. Realizing that public health nurses are essential to the carrying on of child welfare work, we recommend that every possible effort be made to prevent these especially trained nurses from being withdrawn from such work, and that public health nursing be officially recognized as war service.

3. Recognizing the increasing need for trained nurses and the inadequate number available for military and home service, we recommend especially

efforts to enlist graduates of colleges and high schools and other suitable candidates for hospital training courses.

4. Organized volunteer aids should be enlisted to assist public health nurses and other social workers through all practicable methods of personal service. We advise appropriate courses of training for such volunteers.

5. We recommend that the Council call on all communities to see to it that there is no abatement, but, on the contrary, a decided increase, in their activities along the lines of maternal, infant, and child welfare—this to apply to all public and private agencies.

6. We deplore the breaking up of the home and recommend that everywhere special provision be made to keep the mother and her young children together in the home; but this does not imply the endorsement of the home work system.

Mothers of nursing infants should be provided for through mothers' pensions or otherwise.

Day nurseries should be especially supervised, and reference should be had to the standards of the National Federation of Day Nurseries. The highest standards should be required of all children's institutions.

7. We urge that the Council of National Defense recommend the prompt enactment of model laws for the registration of births and deaths and the reporting of preventable diseases in the states in which such laws do not exist, and we strongly urge their complete enforcement throughout the country.

8. We urge that every effort be made not only to prevent the repeal or relaxation of any of the existing child labor laws, but we urge on the contrary their more rigid enforcement and the enactment of such further laws as may be needed.

We recommend a plan of supervision similar to that adopted by the National Child Labor Committee in Pamphlets 276 and 277.

9. For the sake of obtaining the highest possible development of child life, and as one of the best means of conserving the character and moral tone as well as physical development of the growing child, we recommend the extension and use of all sound recreational facilities.

10. Appreciating that no plan for real child conservation in war time can be developed without a serious consideration of the mentally defective child and the juvenile delinquent, and especially because of the great increase in juvenile delinquency in Europe since the war, we urge the Council of National Defense to recommend to the various states that greater facilities be created for the recognition and handling of these problems, through the schools, medical teaching, juvenile court work, and children's institutions.

11. We recommend proper medical examination and supervision for boys and girls entering volunteer organizations involving physical exercise.

12. We urge as particularly important the medical examination of boys and girls before they enter industry; also subsequent medical oversight for them.

13. We recommend systematic publicity and free circulation of accredited literature on maternal, infant, and child welfare. Since many organizations are distributing pamphlets and literature broadcast, some good and some poor, we recommend that a committee of obstetricians, pediatricians, sanitarians, and nurses be appointed to review and standardize such literature for wider distribution.

14. We strongly endorse the measures taken by the Army and Navy authorities for the moral protection of the military forces, and endorse also liberal recreational facilities as an indispensable measure to that end.

15. We urge that immediate steps be taken to secure the adoption of a governmental plan to assure adequate support for soldiers and their families. This plan should include financial and medical provision, facilities for the reeducation of the injured soldier, and the reestablishment of the family. Such a plan promptly put into operation would have more effect in promoting child

welfare than any other measure which the government could adopt on behalf of the dependents of men in service.

16. This country should be warned by the mistake of the European countries which have allowed the milk supplies to become impaired. It should therefore take the necessary steps to prevent a milk shortage. We protest against the indiscriminate slaughter of milch cows.

17. We urge the Council of National Defense to ascertain whether there is need among the allied nations for maternity care and infant and child welfare work that can properly be performed by Americans, and if this be the case, that the Council confer with suitable persons or organizations with a view to rendering such service.

18. We recommend that the Council of National Defense organize a national committee representative of maternal, infant, and child welfare associations, to keep in touch during the present emergency with national problems of maternal, infant, and child welfare, and to advise the Council of National Defense from time to time of such features of the then existing situation as may call for remedial action.

We recommend further, that the Council of National Defense, through the several state councils of defense, cooperate with local organizations interested in maternal, infant, and child welfare and establish an agency or appoint an existing agency to secure information as to the specific needs of each community and to show how such needs can be adequately met.

We recommend that so much of this report as may be approved by the Council of National Defense be transmitted to the state councils of defense and to the proposed national and state committees recommended above, if such committees be created, or designated, to guide them in their respective actions looking toward the conservation of maternal, infant, and child welfare during the present emergency.

For the information of the Council of National Defense, a list of those participating in the formulation of this report is appended.

CONFERENCE ON CHILD WELFARE
By (Signed) WILLIAM C. WOODWARD,
Chairman.

MEMORANDUM SHOWING THE OFFICIAL RELATIONS OF THE PERSONS PARTICIPATING IN THE FORMULATION OF THE ATTACHED REPORT

DR. F. F. SIMPSON, Washington, D. C., Chief of Medical Section, Council of National Defense.

DR. WILLIAM F. SNOW, New York, Assistant Chief of Medical Section, Council of National Defense.

DR. WILLIAM C. WOODWARD, President, American Association for the Study and Prevention of Infant Mortality; Member, General Medical Board, Advisory Commission of the Council of National Defense; Health Officer, Washington, D. C.

DR. FRITZ B. TALBOT, Boston, American Pediatric Society; Section on Diseases of Children, American Medical Association.

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DR. THEODORE C. MERRILL, Sub-Committee on Welfare, Committee on Labor, Advisory Commission of the Council of National Defense.

DR. J. H. MASON KNOX, JR., Baltimore, American Association for the Study and Prevention of Infant Mortality.

Miss Julia C. Lathrop, Chief, Children's Bureau; Chairman, Child Welfare Committee, Woman's Committee, Advisory Commission of the Council of National Defense.

Dr. Grace L. Meigs, Children's Bureau.

Miss Mary Beard, Chairman, Committee on Nursing, Advisory Commission of the Council of National Defense; Director, Instructive District Nursing Association, Boston.

Mrs. Ellen C. Lombard, United States Bureau of Education.

Dr. William H. Davis, Chief Statistician for Vital Statistics, United States Bureau of the Census.

Miss Mary Dietzler, Washington, D. C.

Miss Gertrude B. Knipp, Executive Secretary, American Association for the Study and Prevention of Infant Mortality, Baltimore.

Mrs. William Putnam, Woman's Municipal League of Boston; Massachusetts Milk Consumers' Association; Vice President, American Association for the Study and Prevention of Infant Mortality.

Mrs. Elmer Blair, Chairman, Public Health Department, General Federation of Women's Clubs.

Dr. Frederick R. Green, Chicago, Council on Health and Public Instruction of the American Medical Association.

Dr. Walter E. Fernald, Superintendent, Massachusetts School for the Feeble-minded; Member of National Committee for Mental Hygiene.

Dr. Jessica I. Peixotto, Committee on Children, State Board of Charities and Correction of California; Professor of Social Economics, University of California.

Dr. Frank S. Churchill, Chicago, American Pediatric Society; Section on Diseases of Children of the American Medical Association; Editor, American Journal of Diseases of Children.

FOCAL LESIONS PRODUCED IN THE RABBIT BY COLON BACILLI ISOLATED FROM PYELO-CYSTITIS CASES *

HENRY F. HELMHOLZ, M.D., AND CAROL BEELER
CHICAGO

The mode of infection in pyelocystitis of the infant and child is still far from settled. Much evidence has been brought forward for each of the three routes of infection, the hematogenous, the lymphogenous, and the ascending. In each case the evidence adduced is generalized, and the route of infection made probable by the investigator's observation is claimed as the only possible one. De facto, these observations do not at all preclude the other routes of infection. When we examine the facts as they are at the present time we realize that we do not know what portion of the urinary tract is infected in the condition that is usually termed pyelocystitis. We do know that those cases that come to necropsy usually show some involvement of the kidney pelvis, but that does not prove that a great many of the cases that we see with pus in the catheterized specimen of bladder urine are not merely cases of cystitis. Until these cases are studied more carefully, we must leave this an open question.

Recently the hematogenous mode of infection has been given a great deal of prominence by the work of Cabot and Crabtree,[1] Kowitz[2] and others, who regard the hematogenous route as the only mode of infection. Smith[3] comes to the same conclusion and meets the main argument against the hematogenous mode of infection, the predominance of cases in the female, by assuming that "many cases in the female, accounting for the greater number in this sex as compared with the males, arise from bacteria entering the blood, often via the

* Submitted for publication May 28, 1917.
* From the Otho S. A. Sprague Memorial Institute Laboratory of the Children's Memorial Hospital.
* Read at the meeting of the American Pediatric Society, White Sulphur Springs, W. Va., May 28, 1917.

1. Cabot and Crabtree: Etiology and Pathology of Nontuberculous Renal Infections, Surg., Gyn. and Obst., 1916, p. 495.

2. Kowitz: Ueber bacterielle Erkrankungen der Harnorgane im Säuglingsalter, Jahrb. f. Kinderh., 1915, p. 309.

3. Smith, R. M.: Recent Contributions to the Study of Pyelitis in Infancy, AM. JOUR. DIS. CHILD., 1916, **12**, 273.

lymphatics from the urethra, vulva or vagina." He does not give any evidence, however, in support of this theory, and merely assumes that this may take place.

It seemed to us rather important, therefore, to determine whether or not pyelocystitis could be produced by the hematogenous route. The literature in this connection is very meager. Barlow[4] injected animals intravenously with colon bacilli, without any very definite results. More recently Rosenow's[5] work in the selective localization of bacteria, especially the streptococcus, has called attention to the tendency of bacteria to settle in definite organs. Although his publications do not deal with the colon bacillus alone, he shows that when colon bacilli are injected with streptococci, the tendency is to get lesions in the appendix, gallbladder and intestines. In a series of 31 animals, 26 had lesions in the appendix, 4 of the gallbladder and 13 of the intestine; as compared with only 4 positive findings in a series of 59 animals injected with the streptococci alone. When the colon bacillus alone was injected lesions were very infrequent. This symbiosis is rather interesting when taken in connection with our experiments, in which a mixture of colon bacilli and pneumococci was injected. As in the work of Rosenow, our takes in the kidney were very much more frequent when a mixture of organisms was injected. In order to bring out this difference more strikingly we have kept the two series separate. Series 1 consists of eight different strains of *Bacillus coli* injected intravenously into sixty-six rabbits. Series 2 consists of a mixture of *Bacillus coli* and the pneumococcus injected intravenously into eleven animals.

TECHNIC

The technic employed in the experiments was as follows:

For twenty-four hours before injection the animals were put on a bread and water diet so as to have an acid urine at the time of injection. In every instance the urine was examined before injection for pus cells and albumin. The animals were injected into the ear vein with 0.5 to 1 c.c. of a bacterial suspension, made by centrifuging 15 c.c. of a twenty-four-hour broth culture, and suspending the bacilli in 5 c.c. of salt solution. As indicated in the protocols, the injections were single or repeated.

SERIES 1: In this series of 66 animals, 26 showed focal lesions of one kind or another. The organs were affected as follows: Kidneys 11 times, cecum 7 times, gallbladder 7 times, appendix 5 times, and stomach 4 times; in addition, there were single instances of hemorrhagic infarction of the descending colon, ulcerative colitis, hemor-

4. Barlow: Cystitis, Arch. f. Dermat. u. Syph., 1893.

5. Rosenow: The Bacteriology of Appendicitis and Its Production by Intravenous Injection of Streptococci and Colon Bacilli, Jour. Infect. Dis., 1915, p. 240.

rhagic enteritis, and duodenal hemorrhage. In Table 2 the positive results have been tabulated.

Taking up the different organs in the order of the table, we find that the appendix was affected in five instances; in two of these there was a typical acute purulent hemorrhagic appendicitis, with gangrene near the base of the appendix in the one. This appendix is shown in Figure 1. In the three other instances the appendix showed considerable subserous edema and numerous small hemorrhages.

The stomach was affected in four instances. In two instances there was an unusual number of small hemorrhages in the mucosa, and in one instance there was a phlegmonous gastritis, most marked at the

TABLE 1.—CHARACTERISTICS OF ORGANISMS USED IN SERIES 1

Organism	Motility	Indol	Gelatin	Litmus Milk	Dextrose	Lactose	Saccharose
B. Coli Communis Injected in:							
B. Series C.....	+	+	0	Acid and Coag.	+	+	0
P. Series H.....	+	+	0	"	+	+	0
S. Series H.....	+	+	0	"	+	+	0
B. Coli Communior Injected in:							
J. P. Series C, D and E	+	+	0	"	+	+	+
C. Series L.....	+	+	0	"	+	+	+
L. Series C.....	+	+	0	"	+	+	+
B. Series F and G	+	+	0	"	+	+	+
B. Paracolon Injected in:							
E. Series C.....	+	+	0	Acid; alk. after 48 hours	+	0	0
L. Series H.....	+	+	0	"	+	+	0
Organisms used in Series 2							
B. Coli Communior and Pneumococcus	+	+	0	Acid and Coag.	+	+	+

pyloric end and involving almost one-half of the stomach. The stomach wall was immensely thickened and edematous, especially the muscular coats, and microscopic sections showed diffuse leukocytic infiltration and edema. The fourth instance was a typical gastric ulcer, with a markedly edematous margin, and numerous small hemorrhages in the base. Cultures from the surface of the ulcer and deep down in the tissues yielded only a colon bacillus. This organism was reinjected into a series of animals without producing an ulcer in any one of them.

The gallbladder was affected seven times. The lesions varied from a slight thickening, with minute hemorrhages, to a purulent cholecystitis with fibropurulent gluing together of the stomach, colon and liver. The relatively large number of rabbits that showed coccidiosis

of the gallbladder may account for the number of gallbladder infections that were produced.

The cecum was involved in seven instances. The lesion was a peculiar edematous induration that involved only a few centimeters of the cecum or extended over from 12 to 15 cm. of the entire wall. Figure 2 shows very well the peculiar edematous swelling of the entire wall and also the peculiar hemorrhagic necroses at the tops of the folds

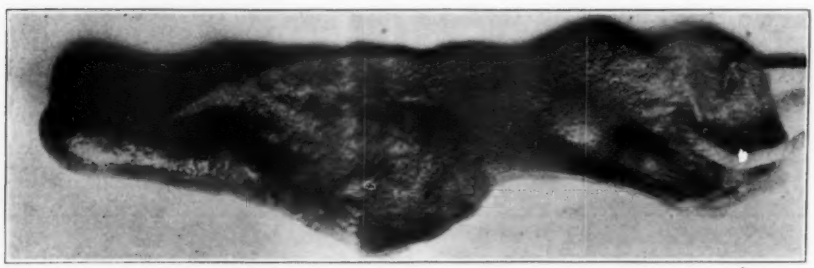

Fig. 1.—Hemorrhagic appendicitis.

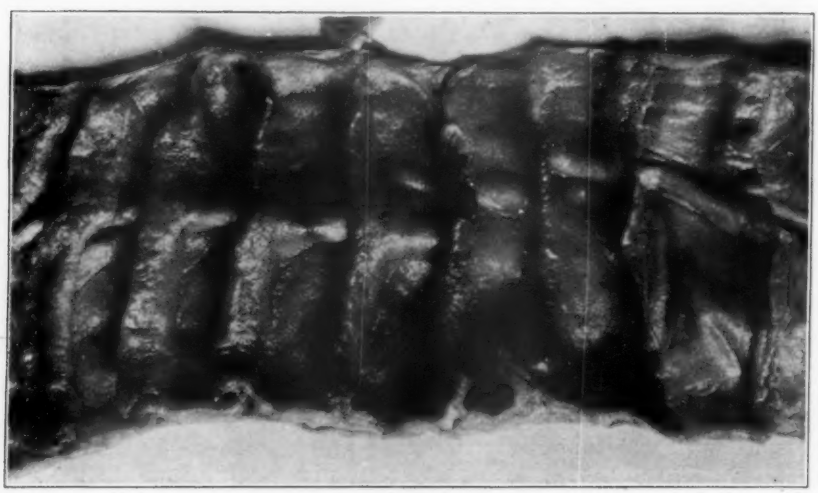

Fig. 2.—Edematous induration of the cecum.

of the mucous membrane. In several instances a diphtheritic exudate could be seen on the tips of the folds. In some the edema was the most marked condition; in others the hemorrhagic condition of the mucous membrane. On section, the lesions proved to be a tremendous inflammatory edema with necrosis of a large portion of the mucous membrane at the tips of the folds. There was also to be seen an inflammatory exudate on the peritoneal surface.

TABLE 2.—DATA OF EXPERIMENTS IN SERIES 1

No.	Animal	Date	Source and Amount Injected, C.c.	Days Until Death	Appendix	Stomach	Gallbladder	Cecum	Kidney				Urine			Remarks
									Hemorrhage	Cortical Abs.	Medullary Abs.	Pyelitis	Albumin	Pus	Culture Colon	
1	R 1X....	5/23 5/24	½ R1V.. ½.....	D 4	+	+	0	0	0	0	+	0	+	0	+	Phlegmonous gastritis; pel. culture, gram negative bacillus
2	R X.....	5/23 5/24	½ R1V.. ½.....	D 3	0	0	0	+	0	0	+	0	+	..	+	Pelvis culture, gram negative bacillus
3	R X111..	5/27	1 RX....	D 1	0	0	0	+	0	+	+	0	+	..	..	Necropsy 24 hours after death
4	R 2D....	5/30 5/31	⅛..... 1 R1X...	D 3	0	0	0	+	0	+	0	0	..	0	+	
5	R 3D....	5/30 5/31	⅛ R1X.. 1.....	S 3	0	+	0	0	0	0	0	0	..	..	0	Stomach ulcer; pure culture, gram negative bacillus from base of ulcer
6	R 4D	5/30 5/31	½ R1X.. 1.....	S 3	0	0	+	0	0	0	0	0	..	..	..	Culture of gallbladder, pure gram negative babacillus
7	R 5D....	5/30 5/31	1/10 R1V ½ app...	S 4	0	0	+	0	0	0	0	0	..	0	+	Culture of gallbladder, pure gram negative bacillus
8	R 6D....	5/30 5/31	⅛ app... ½.....	D 2	0	0	0	0	0	0	0	0	+	0	..	Hemorrhagic infarct. of desc. colon; kidney culture, pure gram negative bacillus
9	R 10D...	5/30 5/31	⅛ app... ½.....	D 2	0	0	0	+	0	0	0	0	..	..	..	Peritonitis; hemorrhage in bladder
10	R 11D...	5/30 5/31	⅛ app... 1.....	S 4	0	0	0	0	0	0	0	0	+	+	+	Hemorrhage in bladder
11	R 1E....	6/ 3	½ R4D..	S 3	0	0	+	0	0	0	0	0	..	..	..	
12	R 2E....	6/ 3	1 R4D...	D 3	0	0	+	0	+	0	0	0	..	..	..	
13	R 4E....	6/ 3	½ R3D..	D 2	0	0	0	+	0	0	0	0	..	..	..	
14	R 1H....	6/21	1 N. L...	D 2	+	0	0	0	+	0	0	0	..	..	0	
15	R 2H....	6/21	1 N. L...	D 2	+	0	0	0	0	0	0	0	..	..	..	Peritonitis
16	R 5H....	6/22	1..... Perin....	Dying D 1	+	0	0	0	0	0	0	0	0	0	+	Marked hemorrhage into duodenum
17	R 9H....	6/23	1.....	D 1	+	0	0	+	0	0	0	0	0	0	..	Hemorrhagic enteritis
18	R 11H...	6/26	Sullivan Bl. of... R8H.....	Dying 1 S	0	+	0	0	0	0	0	0	0	0	0	Enteritis; hemorrhage in duodenum
19	R 2K....	6/28	Bl. R7G. 1.....	S 5	0	0	0	0	0	0	0	+	+	R O L +	+ ..	Pus from left, clear urine from right ureter
20	R 6K....	6/28	Bl. R7G. 1.....	S 5	0	0	+	0	0	0	0	+	+	R + L O	+ ..	Pus from right ureter; clear urine from left
21	R 7K....	6/28	Bl. R7G. ½.....	D 2	0	0	0	+	0	+	+	0	0	0	+	Peritonitis
22	R 15K...	7/ 4	Bl. R2K. 1.....	D 3	0	0	0	0	0	0	0	0	+	+	..	Ulcerative vaginitis
23	R 17K...	7/ 4	Bl. R2K. 1.....	D 4	0	0	+	0	0	0	0	0	..	..	..	
24	R 1L....	7/12	3.....	S 4	0	0	+	0	0	0	0	0	0	0	..	
25	R 3L....	7/13	½ cult...	D 2	0	+	0	0	0	0	+	0	+	+	..	
26	R 4L....	7/13	¼ cult...	D 1	0 *5	0 *4	0 *7	0 *7	+ *3	0 *3	0 *5	0 *2	+ *10	0 *5	0 ..	Infection of colon

* Totals.

The kidney showed focal lesions eleven times; inasmuch as three of these were only hemorrhages of very slight extent, in two of the instances only seen microscopically, it must be considered doubtful whether they have any definite relationship to the colon bacillus injections. The remaining eight animals showed kidney lesions as follows: three had cortical abscesses, three had medullary abscesses, and two had a unilateral pyelitis.

Cortical Abscesses. — In one rabbit the cortical abscesses were apparently of very recent origin and had not spread along the tubules, down into the medulla. In the other two, the abscesses had involved the medulla also. In one of these animals the abscesses were visible

Fig. 3.—Cortical abscesses.

to the naked eye as small, opaque, yellowish nodules in the surface of the kidney, which on section could be seen extending down into the medulla, as seen in Figure 3. In the other of these two animals, the lesions were only discovered in the microscopic examination of the kidney section. The abscesses in the cortex were very minute, involving one or two glomeruli, and those in the medulla showed a tubule or two filled with pus, about which there was some infiltration. The pelves in both of these cases were normal in the sections examined.

Medullary Abscesses.—Two of the three cases showed practically the same condition, a practically normal, reddish-brown kidney externally, and on section, small, yellowish, opaque nodules in the medullary portion of the kidney. These proved to be minute abscesses in which numerous bacilli could be demonstrated. The third rabbit showed a very different picture; the kidney was very much swollen and slightly discolored by postmortem changes, but showed in spite of that, very

extensive abscesses in the medulla; the cortex as far as abscess foundation went was practically intact. The medulla was fairly studded with abscesses extending down along the tubules as seen in Figure 4.

Pyelitis.—Of the sixty-six animals injected, only two showed a typical pyelitis, and in both instances the pyelitis was unilateral. In both instances pus could be expressed from one ureter and clear urine from the other; and on section of the kidney pus welled out of the pelvis in one and a small amount of clear urine out of the other. Histologically, the kidneys of the unaffected and affected side were practically identical, except that in the one the pelvis was filled with pus; in the other not. Changes in the wall of the pelvis were manifest only in an excessive number of polymorphonuclear cells in certain areas.

Fig. 4.—Medullary abscesses.

The question naturally arises at this point as to what the primary lesion is in pyelitis, and why should one get a unilateral pyelitis in these two cases? It emphasizes the fact that unilateral pyelitis does not necessarily point toward the lymphatic mode of infection, but that bacteria may lodge in one kidney and grow, and not in the other even when larger doses are given intravenously than could ever be conceived of in human pathology.

SERIES 2: Over against Series 1 we wish briefly to summarize experiments of Series 2 (Table 3), consisting of eleven animals which were injected with a mixed culture of pneumococci and colon bacilli isolated from a severe case of bronchitis and pyelitis, in which on catheterization only a glass catheter full of practically pure pus could be obtained just before death. Of the eleven animals injected, six showed focal lesions of the kidney; three had a pyelitis; one had cortical abscesses, and two had diffuse hemorrhages in the cortex.

TABLE 3.—Data of Experiments in Series 2

No.	Animal	Date	Source and Amount Injected, C.c.	Days Until Death	Appendix	Stomach	Gallbladder	Cecum	Kidney				Urine			Remarks
									Hemorrhage	Cortical Abs.	Medullary Abs.	Pyelitis	Albumin	Pus	Culture Colon	
1	R 2F...	6/ 9	S & C... 1.....	S 8	0	0	0	..	..	..	..	+	+	+	C + P +	
2	R 3F....	6/ 9	S & C... ½.....	S 6	..	..	+	..	..	+	..	..	+	+	C + P +	Pericarditis; culture, pure pneumococcus; pneum. and colon from pelvis of both kidneys
3	R 4F....	6/ 9	S & C... 1 B.....	S 8	0	0	0	0	0	0	0	+	+	+	C + P +	
4	R 39G...	6/17	S & C... 1 Kid. of R3F	D 2	+	0	0	+	+	0	0	0	.	0	C +	Pure culture B. coli from appendix; culture from kidney cortex negative
5	R 49G...	6/19	S & C... 1 Kid. of R3F	S 2	0	+	0	0	+	0	0	0	+	0	0	
7	R 79G...	6/20	S & C... 1 Kid. of R3F	Dying 7 S	0	0	0	0	0	0	0	+	+	+	C +	
					*1	*1	*1	*1	*2	*1	*0	*3	*5	*4	..	

* Totals.

The hemorrhages in the one were very severe, as over two-thirds of the kidney surface was hemorrhagic; in the other the hemorrhages, though less severe, were more marked than in any of the rabbits injected with colon bacilli alone.

Cortical Abscesses.—In the one case with cortical abscesses the lesion was very widespread. There were large, yellow, raised areas on the surface of the kidney that extended down in wedge-shaped areas to the tips of the papilla.

Pyelitis.—Of the three cases of pyelitis, one must be put in the doubtful column, because the diagnosis of pyelitis rested on the finding of masses of pus cells in the pelvis of the kidney as well as in the cross-section of the ureter histologically, without having found any in the specimens of urine examined, and without any findings macroscopically at necropsy. In the second there were pus cells in the urine, but a practically empty pelvis at necropsy. Histologically, however, there were seen in section definite areas of leukocytic infiltration in the pelvis wall.

In the third case the kidney substance was normal in both, except that the medulla looked somewhat edematous; the pelvis in both kidneys exuded thick creamy pus when opened up. The pelvic mucous membrane was practically intact in the sections studied, but the lumen of the pelvis was filled with a solid mass of polymorphonuclear leukocytes, red blood cells and mononuclear cells.

These three cases emphasize again the difficulty of a study of pyelitis. The first two would have been simply overlooked if sections had not been studied, and it is readily conceivable that a section taken in another portion of the kidney would not have showed these changes.

As controls for these experiments, we injected four different strains of colon bacilli isolated from the intestinal canal of infants suffering from slight intestinal disturbances. Three animals were injected with each strain. Of the twelve injected, in only one animal were there any local findings. This was a purulent appendicitis. The urinary examinations in all the animals were entirely negative; not a single animal showed pus or albumin in any of the examinations made.

The results of the experiments were a considerable surprise. We had anticipated a much larger series of takes in the kidney than were obtained. In Series 1, of the sixty-six animals injected, only eight, about 12 per cent., showed lesions that could be attributed to the *Bacillus coli.* In the same series the appendix was involved 5 times, the stomach 4 times, the gallbladder and the cecum each 7 times. It is thus evident that of the eight organisms used, none showed a special tendency to localize in the kidney, and when it did localize the focal lesions were just as likely to be in other organs, especially the gastro-

intestinal tract. The most characteristic lesion of the colon bacillus appeared to be the edematous infiltration of the cecum. It would seem that the rabbit in almost 90 per cent. of instances can excrete colon bacilli through the kidney without any harm to the kidney. If we compare this with the results obtained by injecting a mixture of pneumococci and colon bacilli, we find that the kidney is more frequently affected. In six out of eleven rabbits, or in 60 per cent., the mixture caused definite lesions in the kidney. This increase of focal lesions corresponds closely to the difference in appendiceal localization described by Rosenow, when a mixture of colon bacilli and streptococci was injected. The question naturally arises whether in human pyelocystitis there is frequently a double infection. The second organism may be easily overlooked, because cultures are usually not made early when both organisms would most likely be present, and if present the colon bacillus tends to overgrow the other. In two cases of hematogenous streptococcus pyelitis in the rabbit we could observe that the colon bacillus made its appearance later, and still later completely displaced the streptococcus.

CONCLUSIONS

1. It is possible to produce typical pyelocystitis in the rabbit by the intravenous injection of colon bacilli isolated from human cases.

2. If a mixture of organisms is injected, the relative number of kidney infections can be greatly increased.

PROTOCOLS

Rabbit 1X.—Weight, 1 pound 3¼ ounces.

May 23, 1916. Urine dark yellow; amorphous precipitate; alkaline. Microscopic: amorphous precipitate; 0.5 c.c. bladder culture of Rabbit 1V injected intravenously; bread diet.

May 24. Urine acid; negative; 0.25 c.c. bladder culture Rabbit 1V reinjected intravenously.

May 25. Urine dark yellow, thick, slightly cloudy, strongly acid, slight trace of albumin. Microscopic: few cells; no precipitate; no bacteria. Stained urine, no bacteria.

May 26. Urine yellow, cloudy, thick, acid; albumin +.

May 27. Rabbit died.

Necropsy.—On opening the peritoneum there is a fibrinous exudate over the upper portion of the abdominal cavity. The stomach is deeply injected and also the ascending portion of the duodenum. The appendix is about the size of a little finger, firm, of yellowish opaque color, deeply injected, in one area greenish black and necrotic looking. On opening the appendix the wall is thickened and hemorrhagic. The lumen is filled with hemorrhagic, yellowish-brown detritus. The duodenum on opening shows areas in which there have been numerous hemorrhages. The stomach wall is intensely thickened and edematous in the pyloric region, less markedly so in the cardiac end. The kidneys are of a brownish-red color, the capsule strips readily. There is nothing unusual externally. On section midway between cortex and papilla there are numerous fine yellowish streaks and spots about 1 mm. across.

May 29. All cultures were of an atypical colon bacillus. Bladder urine acid; no excess of cells; albumin + +.

Histology.—Section 5: The stomach shows an enormous edematous swelling of the submucosa. Most of the cells in the edematous area are lymphocytes. There are numerous hemorrhages into the muscularis.

Section 3: The pancreas and duodenum show marked hemorrhages into the submucosa; also in the muscle and parenchyma. The tissues are well preserved.

Section 4: The liver is negative except for cloudy swelling.

Section 5: Appendix. There is no mucosa left. There is massive infiltration of the lymphatic tissue, with a large area of necrosis and hemorrhages. The muscle layer is densely infiltrated.

Section 6: Kidney. There are miliary abscesses in the central portion of the medullary portion. The medulla in large area is densely infiltrated with lymphocytes, separating the collecting tubules. The cortex shows only slight swelling. There are no hemorrhages.

Rabbit X.—Weight, 1 pound 3 ounces.

May 23. Urine clear; slight amount of phosphate precipitate. Microscopic: no cells; no albumin; alkaline; 0.5 c.c. bladder culture Rabbit 1V injected intravenously; bread diet.

May 24. Urine acid, negative. Reinjected with 0.5 c.c. bladder culture from Rabbit 1V.

May 25. Urine bright yellow, clear, acid; albumin, a trace. Microscopic: no cells; slight precipitate; no bacteria; stained urine, no bacteria.

May 26. Died.

Necropsy.—No distention of bladder. Bladder and pelvis of right kidney were cultured. The kidneys are of reddish-brown color, with no external changes. The capsule strips readily. On section the cortex is slightly more opaque than usual. There is no mottling. The pyramids, beginning about the middle, are studded with small yellowish opaque dots and streaks extending down toward the papilla; the pelvis is everywhere smooth. No injection or hemorrhage is to be made out in either kidney. The lungs and heart were negative. The other organs were negative.

May 29. Pelvis of kidney and bladder yielded a pure culture of colon bacillus. (J. P.)

Rabbit X111.—May 27. Bladder culture from Rabbit X injected intravenously. Urine acid, clear, pale, straw color; albumin, 0.

May 28. Died.

Necropsy.—A loop of colon is covered with tags of purulent exudate, markedly injected, and a hemorrhage on the surface covers an area 2 cm. in diameter. Appendix normal; heart and lungs, and kidneys negative on macroscopic examination.

Histology.—Kidney: There are miliary abscesses in the cortex involving several glomeruli; glomeruli filled with pus cells. In the tubules of the medulla near the tip of the pyramid are several tubules distended with a purulent exudate. One has extended to the tissue between the tubules. In the same portions of the kidney there are tubules filled with masses of bacilli. The pelvis of the kidney shows no change. Colon: The tissue is infiltrated with red blood corpuscles and almost entirely necrotic; only the muscular layer still shows nuclear stain.

Rabbit 2D.—Weight, 15 ounces.

May 30. Cultures of kidney of Rabbit 1X, 0.2 c.c. injected intravenously. Urine entirely negative on examination.

May 31. Reinjected, 1 c.c.

June 2. Died.

Necropsy.—On opening the peritoneal cavity the cecum just at the ileocecal

valve is thickened and hemorrhagic; on opening up this portion of the cecum it is seen to be edematous. The wall is considerably infiltrated, the rugae thickened and numerous hemorrhages on the mucous surface. The kidneys are smooth, of a brownish-red color, and show just under the capsule numerous yellow, opaque nodules about 5 mm. in diameter. The bladder shows some hyperemia of the walls. The gallbladder lies free, studded with white areas similar to Rabbit 4D but not so marked. The other organs are normal.

The urine shows casts and a large number of epithelial cells. Cultures from bladder and cortex of kidney give a colon bacillus.

Histology.—Cecum: There is practically a phlegmon of the entire wall. The submucosa is rich with purulent exudate; mucosa hemorrhagic; only few acini of epithelium remain; muscularis infiltrated with pus cells.

Rabbit 3D.—Weight, 15½ ounces.

May 30. One c.c. culture from kidney of Rabbit 1X injected.

May 31. One c.c. reinjected.

June 2. Sacrificed.

Necropsy.—The abdominal cavity is entirely negative, the cecum and appendix are normal. The bladder is distended. The stomach and duodenum are normal externally. On opening the stomach the cut passes through an ulcer, measuring about 4 mm. across. The ulcer is sharply defined, with a yellowish base, in which are numerous hemorrhages; the edges are thickened, markedly edematous and somewhat wavy. The base is on the muscular layer. Cultures from base and edematous area around the ulcer gave a gram-negative bacillus, an atypical colon bacillus, as was the original J. P. organism. The bladder culture was negative.

Histology.—Section of Kidney: Marked cloudy swelling and vacuolar degeneration of parenchyma. Medulla and pelvis normal. In some areas, apparent necrosis of epithelium.

Stomach: The ulcer shows very intense reaction about it; very marked edema and polymorphonuclear infiltration. In the ulcer base there are a considerable number of red blood corpuscles. The serosa is intact, although there is considerable infiltration just below it.

Rabbit 4D.—Weight, 15½ ounces.

May 30. One-half c.c. of culture from kidney of Rabbit 1X injected.

May 31. One c.c. injected.

June 2. Sacrificed.

Necropsy.—Findings normal in urinary and gastro-intestinal canal. Gallbladder on external surface hemorrhagic and of an opaque yellowish color. Material removed from it contains large numbers of leukocytes and many gram-negative bacilli. Pus from gallbladder when cultured gave pure culture of gram-negative bacilli—an atypical colon organism similar to the organism originally cultivated from J. P.

Histology.—Section of Kidney: Marked cloudy swelling and vacuolar degeneration. In medulla two-thirds of way to top of pyramid is a small hemorrhage.

Rabbit 5D.—Weight, 12¼ ounces.

May 30. One-tenth c.c. of culture from appendix of Rabbit 1X injected.

May 31. One-half c.c. reinjected.

June 3. Sacrificed.

Necropsy.—On opening the peritoneal cavity the bladder is markedly distended with reddish yellow urine. On folding back, the cecum is adherent to the lower surface of the liver. On peeling back, the stomach, too, is seen to adhere to the lower surface of the liver. These adhesions all seem to be around the gallbladder, extending for some distance along the cecum. The adhesions are of darkish, brownish yellow color, and completely encapsulate the gallbladder, which is covered by the same sort of a fibrinous exudate in its sulcus in the liver. The gallbladder is tense and red where the exudate

has been stripped off. Puncture of the gallbladder shows it to contain a yellowish, thinly purulent material. The smear of contents shows gram-negative bacilli. Kidneys: Slightly enlarged, yellowish-brown, slightly mottled, and on section show a thickening of the cortex. The pyramids and pelves are normal. Cultures from gallbladder and bladder show gram-negative bacilli.

Histology.—Kidney: Intense degeneration of cortex; in some areas, complete necrosis of parenchyma; pelvis and medulla negative.

Rabbit 6D.—Weight, 8½ ounces.

May 30. One-fifth c.c. of appendix of Rabbit 1X injected.

May 31. One-half c.c. reinjected.

June 1. Died.

Necropsy.—Hemorrhagic infarction of descending colon; otherwise negative; culture of kidney shows a gram-negative bacillus. Urine: A few cells; much debris; faintly acid; albumin + +.

Histology.—Descending colon: The entire section is completely infiltrated with red blood corpuscles. The nuclei of the muscles and epithelium are still to be made out. The kidney shows cloudy swelling; otherwise negative.

Rabbit 10D.—Weight, 17½ ounces.

May 30. One-fifth c.c. of culture from appendix of Rabbit 1X injected.

May 31. One c.c. reinjected.

June 1. Died.

Necropsy.—The abdomen is distended. On opening there is an excess of fluid in the peritoneum. The cecum is hemorrhagic and for about 5 inches is covered with fibrinous shreds. The wall is markedly thickened. On opening, the wall is seen to be edematous, the folds hemorrhagic. The remainder of the bowel is injected only where in contact with the cecum. The stomach and duodenum are normal. The kidneys are negative. Cultures from kidney and cecum give gram-negative bacilli. Section 1: Cecum. The mucosa is infiltrated with pus cells and serum. The submucosa is thickened and infiltrated with masses of pus cells.

Rabbit 11D.—Weight, 18 ounces.

May 30. One c.c. of culture of appendix of Rabbit 1X injected.

May 31. One c.c. reinjected.

June 3. Sacrificed.

Necropsy.—The appendix and cecum are normal. The bladder is distended with cloudy urine. The urine contains large numbers of individual cells and masses of cells. On opening the bladder it is seen to be somewhat thickened, hyperemic and has a few hemorrhages. The kidneys are negative externally and on section; the pelvis is normal. Other organs are negative. Culture from bladder, gram-negative bacilli.

Histology.—The kidney shows cloudy swelling. One area has blood on surface of pelvis and no epithelium, probably a postmortem change. The bladder shows marked infiltration with polymorphonuclear leukocytes; hemorrhages and edema.

Rabbit 1E.—Weight, 1 pound 10½ ounces.

June 3. One-half c.c. of gallbladder culture of Rabbit 4D injected.

June 6. Sacrificed.

Necropsy.—Appendix normal; all organs normal. The gallbladder is somewhat thickened and contains thin fluid of a light yellowish color, with numerous white opaque follicles. It is slightly reddened in areas. A smear of the contents shows gram-negative bacilli. Culture shows pure gram-negative bacilli.

Histology.—Kidneys negative, except for marked cloudy swelling. The gallbladder shows areas of necrosis in the wall, with leukocytic infiltration, edema and hemorrhages.

Rabbit 2E.—Weight, 1 pound 12 ounces.

June 3. One c.c. of culture from gallbladder of Rabbit 4D injected.
June 6. Died.

Necropsy.—On opening the peritoneal cavity the upper third of the abdominal organs are seen to be adherent to the parietal peritoneum. The loops of the bowel are injected and glued together and to the liver and stomach. The upper portion of the cecum, in like manner, is glued to the stomach. The liver on its under surface over the region of the bile duct adheres to the stomach and is covered with a brownish-yellow, thick exudate. The omentum is hemorrhagic covering over the stomach. The gallbladder is encased in a sheath of fibrinous exudate which can be peeled back and shows a somewhat distended gallbladder. The adjacent surfaces of the liver also are covered with the exudate. The portion of the stomach adjacent to the liver is injected, and about the pyloris it is considerably thickened and indurated. The inner surface of the stomach shows nothing abnormal. The portion of the bowel which is externally inflamed shows nothing on its internal surface. The cecum and appendix are normal; kidneys normal; heart and lungs normal. There is some stippling of the gallbladder as though of coccidial origin. Cultures made of the gallbladder and intestinal wall show gram-negative bacilli.

Histology.—The heart muscle is negative. There is a large hemorrhage in the kidney at the junction of the cortex and medulla.

Rabbit 4E.—Weight, 1 pound 1¾ ounces.
June 3. One-half c.c. of culture from ulcer of Rabbit 3D injected.
June 5. Died.

Necropsy.—On opening the peritoneal cavity the descending colon and rectum are found thickened, much injected and covered with fibrinous exudate. The cecum at the ileocecal valve shows several areas of minute hemorrhages. Under these areas are seen hemorrhages into one of the folds of the mucous membrane. The stomach and gallbladder are normal; also the kidneys.

Histology.—Cecum: The mucosa is intact. There are marked diffuse and focal hemorrhages into the submucosa and muscularis, but no excess of leukocytes. The edema is marked. Kidney: There is marked cloudy swelling and congestion of the medulla, especially of the pyramidal tips. The pelvis is absolutely negative.

H Series: Rabbit H1.—Weight, 1 pound 15½ ounces.
June 21. One c.c. of culture from urine of N. L. injected.
June 21. Urine alkaline; no cells; albumin, 0.
June 22. Rabbit very ill; diarrhea.
June 23. Died.

Necropsy.—Acute hemorrhagic appendicitis. The appendix shows a few peculiar opaque areas near the top. There are minute hemorrhages in both kidneys and a few depressions on the kidney surface. Bladder culture is negative.

Histology.—Numerous hemorrhages in cortex of the kidney, and blood corpuscles in a few of the collecting tubules. The pelvis is negative.

Rabbit 2H.—Weight, 2 pounds ¼ ounce.
June 21. One c.c. of culture from urine of N. L. injected. Urine acid; crystalline precipitate; no cells; albumin ±.
June 22. Abdomen hard; pain when effort was made to express urine.
June 23. Dead.

Necropsy.—A purulent peritonitis was found. The culture of peritoneum shows a pure gram-negative bacillus. The appendix shows marked proliferation of the epithelial cells and phagocytosis of lymphatic cells; no hemorrhages.

Rabbit H5.—Weight, 1 pound 5½ ounces.
June 22. One c.c. of culture from urine of P. injected. Urinary examination entirely negative.
June 23. Dying. Diarrhea.

Necropsy.—Marked distention with fluid of the intestines, and all along the intestinal canal are hemorrhages. The appendix shows numerous hemorrhages along the course but most marked at its attachment to the cecum. The appendix is filled with fecal material, moist at proximal end, dry at the tip. The mucous membrane is intact. The stomach is normal but there are marked hemorrhages into the duodenum. Culture of bladder gives gram-negative bacilli. Examination of urine negative; no albumin.

Histology.—Duodenum: Hemorrhages into mucosa and submucosa. No inflammatory reaction of leukocytes. The mucous membrane is gone in the hemorrhagic areas, although glands deep down remain. The kidney has cloudy swelling. The pelvis of the kidney is intact, showing no excess of cells.

Rabbit H9.—Weight, 1 pound 1¼ ounces.

June 23. One c.c. of culture from urine of S. injected. Urine alkaline; microscopically negative; no albumin.

June 24. Died. Marked diarrhea.

Necropsy.—The bowel is filled with liquid contents. There are numerous hemorrhages on the appendix, especially toward its base. There are a few hemorrhages into the cecum and numerous hemorrhages into the upper portion of the intestine. There was a hemorrhagic enteritis of the upper portion of the ileum. In this area the ileum is filled with hemorrhagic mucopurulent material. The kidneys and gallbladder are negative. Stomach, duodenum and heart are negative.

Histology.—The ileum shows hemorrhages into the mucosa and inflammatory exudate in the submucosa.

Rabbit H11.—Weight, 1 pound 2½ ounces.

June 24. Injected with bladder culture from Rabbit H8; 1 c.c. given.

June 26. Urine examined; cloudy, acid, microscopically negative; albumin negative.

June 27. Animal almost dead; sacrificed. There is no excess of fluid. In peritoneal cavity the organs are normal. The exterior of the duodenum shows a few hemorrhages. The ileum is distended with fluid and shows injection and scattered small hemorrhages. On opening there are hemorrhages (minute in stomach, larger in duodenum) and throughout a large portion of the ileum. The kidneys are yellowish brown and somewhat fatty. The pelvis is negative. The bladder is negative.

Histology.—The kidney shows cloudy swelling. The appendix and stomach show nothing of note.

K. Series: Rabbit 2K.—Weight, 12½ ounces.

June 28. One c.c. of bladder culture of Rabbit 7G injected. Urine examined before injecting. Microscopically negative; acid; albumin 0.

June 30. Urine acid; single cells and numerous clumps; a few casts; albumin +.

July 3. Urine acid; many cells and groups of cells; sacrificed. Bladder apparently normal; ureters small, apparently normal. The urine expressed from the right ureter negative; from left, yields pus. The kidneys externally are smooth and of a brownish-red color. On section the right kidney is normal. Cortex and medulla are normal and there is no pus in the pelvis, which appears normal. The left kidney is the same as the right, except that there is pus in the pelvis. Bladder cultured; pure gram-negative bacillus found. Smear of pus from left ureter contains pus cells and gram-negative bacilli.

Histology.—Left Kidney: The cortex, except for cloudy swelling, is normal. The medulla shows nothing unusual. The pelvis is filled with masses of pus cells. In parts, especially on the papilla, the mucous membrane is intact. On the surface of pelvis there is a loss of mucosa for a considerable area; in parts small islands of squamous epithelium remain. On one side is seen a large vessel with a thrombus in it. There is a marked infiltration of the mucous membrane with eosinophils. The right kidney is negative; bladder negative.

Rabbit 6K.—Weight, 1 pound 2¼ ounces.

June 28. One and one-half c.c. of culture from bladder of Rabbit 7G injected. Urine examined; microscopically negative; acid; albumin 0.

June 30. Large amount of dark urine; many hyaline and granular casts; precipitate contains no excess of cells; albumin present.

July 3. Sacrificed. Bladder urine contained pus cells. The rabbit seems in excellent condition. On opening the peritoneum, the bladder is practically empty, the stomach and intestines normal. The gallbladder is covered in the lower half with a fibrinous purulent membrane adherent to the liver. The appendix, stomach and duodenum are normal. The bladder contains a small amount of urine, with excess of pus cells, single and in clusters. The urine expressed from the cut ureter on the right side yields pure pus; on the left side very few epithelial cells. A smear of the pus from right ureter contains gram-negative bacilli. A smear of urine from bladder shows a gram-negative bacillus in pure culture. The right kidney is of a brownish yellow color and smooth on section. The pelvis of the kidney exudes thick yellow pus. The cortex is opaque and yellow; the medulla shows nothing unusual. The left kidney on section shows no pus in the medulla, but in every other way resembles the right. The ureter of the right kidney is considerably smaller. Cultures of gallbladder contents shows a gram-negative bacillus.

Histology.—The epithelium on the pyramid is intact; over the opposite side of the pelvis the epithelium is lost and the surface is made up of a mass of pus cells. There is considerable infiltration of the lining of the pelvis. In the left kidney there is no pus in the pelvis, but a slight increase in connective tissue in the cortex. The bladder is negative.

Rabbit 7K.—Weight, 1 pound 11¾ ounces.

June 28. One and one-half c.c. of bladder culture of Rabbit 7G injected; Urine examined; a few cells and no albumin were found.

June 30. Died.

Necropsy made immediately after death. Peritonitis present; excess fluid; coccidiosis, especially about stomach and duodenum. Bladder contains a small amount of normal urine. Left kidney shows two small yellow opaque areas in cortex. Otherwise negative except for the injection of a portion of cecum near valve. Culture of bladder heavy growth in broth of gram-negative bacillus.

Histology.—There are minute abscesses in kidney, both in the cortex and the medulla.

Rabbit 15K.—Weight, 1 pound 4½ ounces.

July 4. One c.c. of bladder culture from Rabbit 2K injected. Urine examined; microscopically negative, acid; albumin 0.

July 5. Diarrhea; many pus cells and epithelial cells; acid, albumin + +.

July 6. Diarrhea; many pus cells and groups of cells; acid; albumin + +.

July 7. (Weight 15½ ounces; ill); urine loaded with pus cells and groups of cells; acid; albumin + +.

Died between July 7 and 8.

Necropsy.—On opening the peritoneum, hemorrhages are found in the lower portion of the retrovesical tissue; bladder distended with large amount of urine, which does not contain excess of pus cells. Bladder wall on top shows slight thickening; kidneys normal. Stomach and duodenum normal. Gallbladder adhered to the liver and covered with omentum, which is matted together and can be separated from the gallbladder in a thickly purulent area. Along the line of cleavage there is a purulent membrane; appendix, stomach and duodenum normal. Heart negative. Kidneys smooth, uniform in color, on section show nothing unusual. Coccidiosis of liver and gallbladder. Vagina much reddened, and in an area about 3 mm. across there is an opaque, yellowish membrane.

Histology.—The kidneys show nothing abnormal. The vagina shows a pseudomembranous inflammation of the wall, with considerable necrosis.

Rabbit 17K.—Weight 1 pound 8¼ ounces.

July 4. One c.c. of bladder culture of Rabbit 2K injected. Urine examined; microscopically negative; acid; albumin 0.

July 5. Diarrhea. About 20 c.c. of urine expressed; contains a few cells and groups of cells, probably no excess; acid; albumin +.

July 6. Diarrhea; no excess of cells; acid; albumin 0.

July 7. Weight, 1 pound 3½ ounces. Urine examined, negative; cloudy with amorphous precipitate; acid; no albumin.

July 8. Died.

Necropsy.—On opening there is an excess of fluid in the peritoneum. The bladder is markedly distended; the intestinal canal is apparently normal; kidneys are smooth, of a uniform color on the surface. The gallbladder is studded with white opaque areas, and in addition numerous small hemorrhagic areas. The gallbladder is smooth on the external surface. The kidney on section shows nothing unusual. The pelvis is smooth and contains no pus. Nothing is obtained from the ureters.

Histology.—The kidneys show nothing of note.

Series L: Rabbit L1.—Weight, 2 pounds.

July 12. Three c.c. of a sodium chlorid suspension of bacilli from the urine of C. injected. Suspension approximately the same as in the urine. Urine examined; a few cells; urine clear, alkaline; acid to phenolphthalein; no albumin.

July 13. No excess of cells; acid; albumin 0.

July 14. A few cells; acid; albumin +.

July 15. Large number of pus cells; acid; slight amount of albumin. Sacrificed.

Necropsy.—Bladder urine negative; no pus obtained from either ureter; kidneys are negative; no vaginitis. The gallbladder is hemorrhagic, infected and full of pus. The findings otherwise are entirely negative.

Histology.—The kidneys are entirely negative.

Rabbit 3L.—Weight, 2 pounds 1¼ ounces.

July 13. One-half c.c. urine culture of C. injected. Urine examined; microscopically negative; alkaline; albumin 0; cloudy, amorphous precipitate.

July 14. Urine examined; excess of pus cells; acid; albumin 0.

July 14, p. m. One-half c.c. reinjected.

July 15. Urine examined; excess of pus cells; acid; albumin +; weight, 1 pound 11¼ ounces.

July 15 to 17. Died.

Necropsy.—Much decomposed. Bladder urine filled with cellular, apparently epithelial, debris. Epithelial debris from both ureters. Gallbladder shows marked injection, and suppuration; portion of stomach at pyloric end adhering to it is hemorrhagic. Kidneys are large and bluish-brown in color. On section there are seen numerous yellow dots and lines in the medulla; marked degeneration of the cortex; numerous linear abscesses, extending to papilla in the medulla; intense congestion.

Histology.—There are innumerable abscesses in medulla.

Rabbit 4L.—Weight 2 pounds.

July 13, 3:30. One-quarter c.c. of urine culture of C. injected. Urine examined; microscopically negative; alkaline; albumin 0; cloudy, amorphous precipitate.

July 14. Microscopically negative; acid; albumin +.

July 14 p. m. One-quarter c.c. reinjected.

July 14 to 15. Died.

Necropsy.—On opening the peritoneum the descending colon for a distance of about 4 inches is of dark, reddish-brown color and considerably distended. There is a sharp transition at both ends to practically normal intestinal wall. On opening up the colon this region is seen to be markedly hemorrhagic and

somewhat thickened showing the same abrupt transition to normal tissue. The kidneys show a few small hemorrhages in the surfaces. The pelvis shows nothing abnormal.

Histology.—The kidneys are entirely negative.

Rabbit 2F.—Weight, 1 pound 15¾ ounces.

June 9. One c.c. of urinary culture of B. injected. Urine negative for albumin and pus cells.

June 10. Urine acid, cloudy with amorphous precipitate; no cells; albumin +.

June 12. Acid, cloudy, precipitate largely amorphous; some pus cells; many bacteria; albumin +.

June 14. Weight, 1 pound 12¼ ounces. Urine thick and stringy, full of masses and strings of amorphous material; acid; no cells; few bacteria; albumin ±.

June 15. Urine very cloudy; full of amorphous material; a few pus cells; albumin +.

June 16. Urine cloudy; much amorphous material; some pus cells; albumin ±.

June 17. Sacrificed.

Necropsy.—Findings were entirely negative; examination of bladder urine showed many pus cells as well as some amorphous material; urinary culture showed a gram-negative bacillus and gram-positive coccus.

Histology.—Kidney showed slight infiltration of a portion of the pelvis; marked cloudy swelling of parenchyma.

Rabbit 3F.—Weight, 1 pound 6 ounces.

June 9. One-half c.c. of urinary culture of B. injected. Urine negative for albumin and pus.

June 10. Urine slightly acid; brownish-yellow; cloudy with amorphous precipitate; few bacteria; no cells; albumin + +.

June 12. Acid urine; cloudy, amorphous precipitate and masses of shreds and debris of all kinds; albumin + +.

June 14. Weight, 1 pound 1¼ ounces. Urine very cloudy; full of pus cells and motile bacteria; albumin + +; acid.

June 15. Urine cloudy; full of pus cells; albumin + +.

June 16. Urine cloudy; full of pus cells; albumin +. Sacrificed.

Necropsy.—On opening the peritoneal cavity the serous surfaces are everywhere smooth. The bladder is distended with cloudy urine, the ureters are not distended; the kidneys are smooth on the surface but in two places on left and in one place on the right there is an opaque, yellowish area from 1 to 3 mm. in diameter. On section through areas they are seen to extend into the medulla in a long, yellowish streak practically to the papilla. The pelvis shows nothing unusual. The gallbladder is distended; outer surfaces are smooth, and contents consist of thick purulent material. Some coccidiosis of liver. The stomach, duodenum, appendix and cecum show nothing unusual. The pericardium adheres over the entire upper portion of the heart and is covered with a thick, creamy exudate. Culture from the bladder shows a gram-positive coccus and a gram-negative bacillus; also from the pelvis of the kidney and the gallbladder a gram-positive coccus and a gram-negative bacillus; from an abscess of the kidney a gram-positive coccus alone; from the heart, a gram-positive coccus alone.

Rabbit 4F.—Weight, 1 pound 4¾ ounces.

June 9. One c.c. of culture injected. Urine negative for albumin and pus.

June 10. Urine acid; pretty clear; slight amorphous precipitate, no cells or bacteria; albumin +.

June 12. Urine acid; cloudy, amorphous precipitate; no cells; few bacteria; albumin +.

June 14. Weight, 1 pound 3¾ ounces; urine very cloudy; stringy, amorphous masses; no cells; acid; albumin ±.

June 15. Urine cloudy; stringy substance present; few cells; acid; albumin +.

June 17. Sacrificed.

Necropsy.—Findings are entirely negative. Urine cloudy, with amorphous precipitate; no cells. Urine culture showed a gram-positive coccus and a gram-negative bacillus.

Histology.—Kidneys contain numerous pus cells in groups in the pelvis and in the lumen of the ureter. The bladder is negative.

Rabbit 3G.—Weight, 1 pound.

June 17. One c.c. of suspension of culture from kidney abscess of Rabbit 3F injected intravenously.

June 19. Found dead; ill the afternoon of June 18.

Necropsy.—On opening the peritoneum a portion of the ileum just above the ileocecal valve is found reddened and hemorrhagic. The most marked area is found about 1 foot above the ileocecal valve. This portion of the bowel on opening is studded with small hemorrhages, and on a portion of the wall there is a diphtheritic exudate. The appendix is thickened, and in an area about 1 inch below its attachment to the cecum is deeply injected and hemorrhagic and of an opaque, yellowish color. The appendix on opening shows in this hemorrhagic area a hemorrhagic exudate and considerable necrosis of the wall. The urine is cloudy, and on microscopic examination shows some casts and a few pus cells, and a considerable number of epithelial cells. The kidneys are much enlarged, opaque, of yellowish color, studded with groups of minute hemorrhages which give the kidney a mottled appearance. On section the hemorrhages are seen to be limited to the cortex and resemble the appearances on the outside. The heart is negative. A pure culture of a gram-negative bacillus was obtained from the submucosa of the appendix and from the bladder. The kidney cortex culture was negative.

Histology.—The kidney shows numerous hemorrhages in the cortex and considerable degeneration and necrosis of tubules. There are also some minute areas of infiltration in the cortex.

Rabbit 4G.—Weight, 1 pound 8¾ ounces.

June 19. One c.c. of culture from abscess of left kidney injected intravenously. Urine acid; negative.

June 20. A few cells; some amorphous material; slightly acid; no albumin.

June 21. Sacrificed.

Necropsy.—Peritoneum clear; appendix and cecum negative. Gallbladder hemorrhagic. The stomach has few small hemorrhages in the cardiac end; a small ulcer (?). The duodenum has six to eight hemorrhages just beyond the pyloric ring. The heart is negative. The kidneys are large, yellow and pale; cortex smooth but studded with minute hemorrhages over the entire surface; same in both kidneys. There are also small areas of more opaque, yellow appearance. The bladder shows numerous small submucous hemorrhages, one of somewhat larger size. Urine from the bladder shows albumin, epithelial cells, casts and leukocytes. Cultures of the urine are negative.

Histology.—The kidney cortex has no hemorrhages in the sections studied. There is marked degeneration and necrosis of epithelium in areas. The stomach and duodenum show hemorrhages in the mucosa.

Rabbit 7G.—June 20. One c.c. from abscess of left kidney, Rabbit 3F injected. Urine negative; acid.

June 21. Urine contains a few pus cells; acid; albumin +.

June 22. Urine acid; numerous pus cells; albumin +; diarrhea.

June 23. Urine acid; numerous pus cells, albumin +; diarrhea.

June 26. Diarrhea; urine contains numerous cells and groups of cells; albumin +.

June 27. Dying; chloroformed.

Necropsy.—On opening the abdomen the bladder is markedly distended with urine. The serous surfaces are everywhere smooth. The only unusual thing is a peculiar yellowish discoloration of that part of the ileum just above the ileocecal valve. The gallbladder is distended and filled with a thick yellowish material. On opening the chest the right ventricle of the heart is seen to be much dilated and of a yellowish color. The lungs are negative. The bladder shows a perfectly normal mucous membrane. There are no hemorrhages of the wall. The appendix is normal; the cecum is somewhat thickened near the ileocecal valve, and for a distance of about 6 inches above is somewhat thickened and in patches covered with a yellowish membrane firmly adhering to the mucous membrane. The stomach and doudenum show nothing unusual. The right kidney is of a brownish-red color and shows one or two lighter areas. On section it is of about normal thickness and the same color as the external surface. The medulla is somewhat edematous. There is pus in the pelvis of the kidney, but no hyperemia. The ureters and bladder are normal. On the left kidney are opaque yellowish areas which are limited to the cortex. The pelvis contains pus; otherwise nothing unusual. Cultures from the gallbladder and bladder contain a pure gram-negative bacillus.

Histology.—There is infiltration about many glomeruli. The pelvis of both kidneys shows an intact mucous membrane, but just below the epithelium there is a marked infiltration with leukocytes; also in the tips of the papillae. In the colon a diphtheritic membrane covers a large area of the surface. There is complete destruction of the mucosa and submucosa, and massive infiltration and fibrosis of the entire wall.

TWENTY-FOUR-HOUR METABOLISM OF TWO NORMAL INFANTS WITH SPECIAL REFERENCE TO THE TOTAL ENERGY REQUIREMENTS OF INFANTS*

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A series of investigations of the metabolism of normal infants were begun five years ago by Benedict and the writer at the Nutrition Laboratory of the Carnegie Institution of Washington with the object of obtaining a curve of the "basal" metabolism of normal infants. Some of these studies have already been published, and the rest are in the process of completion to be published later. Their primary object is to obtain the "basal" metabolism of infants (the metabolism at rest) for the purpose of comparing health with disease. The basal metabolism should mean that the subject is in complete muscular repose, and in the "postabsorptive" state, that is, when absorption of material from the alimentary tract has ceased. Since it is almost impossible to obtain a period of complete muscular repose in infants in the "postabsorptive" state and hungry, the term "basal" metabolism will be used in this communication in describing quiet periods shortly after food has been given. Since the results of these studies do not take into consideration the extra energy used up in muscular exercise, lost in the excreta or deposited in the body in the form of new tissue, they cannot be used as a definite measure of the food requirements of a normal growing infant. They contain information, however, which, with additional knowledge, helps in estimating the total caloric requirements of infants.

A careful review of the literature shows that there have been few instances in which an attempt has been made to obtain the twenty-four-hour metabolism of normal infants. The fundamental experiments of Rubner and Heubner[1] stand out as giving the only twenty-four-hour figures available for normal infants. They give records of three different normal infants weighing 5, 8 and 10 kg., the first and last being fed on human milk, and the second on a mixture of cow's milk. These infants were inside a respiratory chamber about twenty hours of the twenty-four-hour day. Unfortunately, complete records of the individual periods in these experiments showing the percentage increase in calories from rest to muscular activity are not available. Heubner, on

* Submitted for publication May 28, 1917.

* From the Nutrition Laboratory of the Carnegie Institution of Washington, Boston.

* Read at the meeting of the American Pediatric Society, White Sulphur Springs, W. Va., May 28, 1917.

1. Rubner and Heubner: Ztschr. f. biol., 1898, **36,** 1. Rubner and Heubner: Ztschr. f. biol., 1899, **38,** 315. Heubner: Berl. klin. Wchnschr., 1901, **38,** 449. Rubner and Heubner: Ztschr. f. exper. Path. u. Therap., 1905, **1,** 7.

the basis of these and other studies, maintains that an average normal infant requires per twenty-four hours, 100 calories per kilogram of body weight during the first three months of life, 90 calories during the second three months, and 80 or less calories during the last half of the first year of life. These figures are usually accepted as a basis from which to compute the energy requirements of normal infants.

The great difficulty of obtaining complete records of the respiratory metabolism for twenty-four hours accounts for the paucity of material reported above. The present investigation was carried on under Miss Alice Johnson and assistants, whose careful work and devotion day and night are responsible for the success of a very difficult piece of work, and without whose hearty cooperation it would have been impossible.

The purpose of the present investigation was to determine, if possible, how much extra energy was expended in the ordinary muscular activity of an infant during a twenty-four-hour day. It has been known for a long time that muscular activity increases the metabolism, but, on the other hand, there is no measure of how much of the day the infant is active. If the increase in metabolism due to muscular activity can be determined, if the factor of growth and the factor of energy lost in the excretions be established, this material could be used in conjunction with the average curve of the "basal" metabolism to estimate the number of calories in the food necessary for an infant in a twenty-four-hour day.*

The normal infants in the Directory for Wet-Nurses of the Boston Infants Hospital were selected for this purpose. The plan of the observation was to have the infant inside the respiratory chamber as many hours out of the twenty-four as possible so that an accurate measure of the total respiratory exchange could be obtained.

The periods were started at about 7 p. m., and run through the following twenty-four hours, stopping at the same time the next evening. Short periods were recorded so that it would be possible to select periods of absolute quiet as well as periods of activity. The cover was raised at regular intervals and the baby removed, nursed by his mother, and the diapers changed when soiled. It was due to the intelligent cooperation of the mothers that in one instance the infant was inside the respiratory chamber twenty-two hours and thirty-one minutes, and in the other, twenty-three hours and ten minutes. The flexibility of the apparatus made this possible without impairing the accuracy of the

* A tentative curve may be found in Morse and Talbot, Diseases of Nutrition and Infant Feeding, New York, 1915, p. 61. When such a curve is used the variations from the average should always be borne in mind, if it is applied to a single infant, because averages are made up from several subjects and the extremes may be as much as 10 per cent. one or the other side of the average figure.

results. The length of the actual observation compares very favorably with those of Rubner and Heubner, which were in all instances shorter.

E. L., girl, was born January 27, 1916, full term, the labor was normal and the baby weighed 3.71 kg. (8 pounds, 3 ounces) at birth. She was entirely breast fed up to date, receiving the breast every three hours. She had never been sick. Her weight April 20, 1916, was 5.03 kg. (about 11 pounds). The details of the twenty-four hours during which the respiratory exchange was measured are as follows:

6:48 p. m.—Nursed at breast
7:23 p. m. to 1:10 a. m.—In respiratory chamber. Quieted down. Slept
1:10 a. m. to 1:25 a. m.—Taken out, diapers changed. Nursed nine minutes Returned to chamber
1:25 a. m. to 2:02 a. m.—Restless
2:02 a. m. to 3:15 a. m.—Sleeping
3:15 a. m. to 3:51 a. m.—Moving about
3:51 a. m. to 4:30 a. m.—Quiet
4:46 a. m. to 6:40 a. m.—Moving and cried at intervals
6:40 a. m. to 6:54 a. m.—Taken out, given breast, diapers changed, wet with urine. Returned to chamber
6:54 a. m. to 7:54 a. m.—Played with hands and moved
7:54 a. m. to 8:39 a. m.—Asleep
8:39 a. m. to 9:26 a. m.—Moved hands and twisted body. Taken out, diapers wet, changed. Nursed. Returned to chamber
9:46 a. m. to 10:40 a. m.—Moving and restless
10:40 a. m. to 11:14 a. m.—Quiet
11:14 a. m. to 12:31 p. m.—Grumbling, moving, waving hands, cooing
12:31 a. m. to 12:51 p. m.—Taken out, given breast. Diaper soiled with small, brownish yellow stool. Returned to chamber
12:51 p. m. to 1:45 p. m.—Gradually became quiet
1:45 p. m. to 3:00 p. m.—Twisted, grumbled or played with hands
3:00 p. m. to 3:29 p. m.—More restless
3:29 p. m. to 3:49 p. m.—Taken out, diapers changed, nursed. Returned to chamber
3:49 p. m. to 7:23 p. m.—Moderately active
7:23 p. m.—Taken out

She was weighed before and after each nursing and received amounts of breast milk as shown in Table 1.

TABLE 1.—Amounts of Breast Milk Received by Infant E. L. in Twenty-Four Hours

Date	Time	Grams	Ounces
4/20/16	7:07 p. m.	90	3
4/21/16	1:21 a. m.	135	4½
4/21/16	6:50 a. m.	135	4½
4/21/16	9:42 a. m.	145	4¾
4/21/16	12:48 p. m.	90	3
4/21/16	3:45 p. m.	100	3¼
Total in 24 hr.		695	23¼

TABLE 2.—Results of the Measurements of Gaseous Metabolism of Infant E. L.

Period	Time	Length of Period, Min.	CO_2 Produced		Average Pulse Rate	Respiratory Quotient
			Measured, Gm.	Calculated to Hour Basis, Gm.		
Preliminary	7:23 – 7:53 p. m.	30	2.88	5.76	126	
1st	7:53 – 8:28 p. m.	35	2.46	4.22	117	0.92
2d	8:28 – 9:03 p. m.	35	2.58	4.42	119	0.94
3d	9:03 – 9:39 p. m.	36	2.52	4.20	118	0.88
4th	9:39 –10:14 p. m.	35	2.46	4.22	116	0.86
5th	10:14 –10:51 p. m.	37	2.71	4.39	112	0.91
6th	10:51 –11:27 p. m.	36	2.48	4.13	114	0.88
7th	11:27 p. m.–12:04 a. m.	37	2.31	3.75	115	0.80
8th	12:04 –12:38 a. m.	34	2.22	3.92	115	0.90
9th	12:38 – 1:10 a. m.	32	2.16	4.05	117	0.81
Preliminary	1:25 – 1:53 a. m.	28	2.80	6.00	132	
1st	1:53 – 2:32 a. m.	39	2.78	4.28	121	0.86
2d	2:32 – 3:09 a. m.	37	2.82	4.57	120	0.97
3d	3:09 – 3:58 a. m.	49	3.62	4.43	121	0.87
4th	3:58 – 4:49 a. m.	51	4.33	5.09	122	0.88
5th	4:49 – 5:39 a. m.	50	5.25	6.30	140	0.91
6th	5:39 – 6:15 a. m.	36	2.47	4.12	122	0.84
7th	6:15 – 6:40 a. m.	25	3.01	7.22	152	0.80
Preliminary	6:54 – 7:17 a. m.	23	2.50	6.52	145	
1st	7:17 – 7:56 a. m.	39	4.31	6.63	139	0.88
2d	7:56 – 8:31 a. m.	35	2.78	4.77	117	0.83
3d	8:31 – 9:26 a. m.	55	5.51	6.01	125	0.81
Preliminary	9:46 –10:04 a. m.	18	2.11	7.03	146	
1st	10:04 –10:32 a. m.	28	2.77	5.94	136	0.98
2d	10:32 –11:00 a. m.	28	1.92	4.11	115	0.86
3d	11:00 –11:33 a. m.	33	2.66	4.84	122	0.82
4th	11:33 a. m.–12:08 p. m.	35	3.87	6.63	143	0.90
5th	12:08 –12:31 p. m.	23	2.35	6.13	133	0.86
Preliminary	12:51 – 1:27 p. m.	36	2.87	4.78	119	
1st	1:27 – 2:16 p. m.	49	4.15	5.08	121	0.92
2d	2:16 – 3:29 p. m.	73	8.57	7.04	140	0.85
Preliminary	3:49 – 4:15 p. m.	26	2.84	6.55	128	
1st	4:15 – 4:47 p. m.	32	3.48	6.53	138	0.86
2d	4:47 – 5:14 p. m.	27	2.70	6.00	123	0.90
3d	5:14 – 6:19 p. m.	65	6.44	5.94	143	0.83
4th	6:19 – 6:52 p. m.	33	3.49	6.35	136	0.87
5th	6:52 – 7:23 p. m.	31	3.62	7.01	142	0.85
Total.....		22 hr. 31 min.	120.80	....	...	0.87

The results of the measurements of the gaseous metabolism of E. L., aged 2 months, 3 weeks, weight 5.03 kg., for the twenty-four hours, April 20-21, 1916, are given in Table 2.

E. S., girl, was born at full term, Oct. 14, 1915. She weighed 6 pounds (2.72 kg.) at birth. She was always breast fed and did fairly well until February, 1916, when she had some indigestion and colic, and some facial eczema. These symptoms gradually straightened out, and on April 19, when 6 months and 1 week old, she weighed 5.76 kg. (the average weight for the age is 7.8). She finished nursing at 6:51 p. m., April 19, 1916. The program for the twenty-four-hour day was as follows:

6:51 p. m.—Finished nursing
7:02 p. m. to 5:51 a. m.—Placed in chamber. Quickly went to sleep. Occasional muscular movement recorded on smoked drum
5:52 a. m. to 6:08 a. m.—Taken out, nursed, returned to chamber
6:08 a. m. to 8:13 a. m.—Asleep
8:13 a. m. to 8:51 a. m.—Moderate moves
8:56 a. m. to 9:08 a. m.—Taken out, nursed, returned to chamber
9:08 a. m. to 10:15 a. m.—Cooed, kicked, played, smiled, occasionally cried
10:15 a. m. to 12:14 p. m.—Quiet, very few moves
12:14 p. m. to 12:46 p. m.—More active
12:46 p. m. to 12:57 p. m.—Taken out, nursed, diapers changed, returned to chamber.
12:57 p. m. to 2:08 p. m.—Kicking and waving hands
2:08 p. m. to 2:51 p. m.—Asleep
2:51 p. m. to 3:48 p. m.—Active, crying or laughing
3:48 p. m. to 4:00 p. m.—Taken out, nursed, diapers changed, returned to chamber
4:00 p. m. to 5:19 p. m.—Played, moved and wiggled
5:19 p. m. to 7:03 p. m.—Asleep with the exception of a few minutes of play

She was weighed before and after each nursing and received amounts of breast milk as shown in Table 3.

TABLE 3.—AMOUNTS OF BREAST MILK RECEIVED BY E. S. IN TWENTY-FOUR HOURS

Date	Time	Grams	Ounces
4/19/16	6:51 p. m.	70	2¼
4/20/16	5:56 a. m.	135	4½
4/20/16	9:07 a. m.	125	4¼
4/20/16	12:54 p. m.	150	5
4/20/16	3:57 p. m.	135	4½
Total in 24 hr.		615	20½

The results of the measurements of the gaseous metabolism of E. S., aged 6 months, 1 week, weight 5.76 kg., for twenty-four hours, April 19-20, 1916, are given in Table 4.

TABLE 4.—Results of the Measurements of Gaseous Metabolism of Infant E. S.

Period	Time	Length of Period, Min.	CO_2 Produced		Average Pulse Rate	Respiratory Quotient
			Measured, Gm.	Calculated to Hour Basis, Gm.		
	April 19					
Preliminary	7:02 – 7:23 p. m.	21	1.99	5.69	135	
1st	7:23 – 7:59 p. m.	36	2.76	4.60	120	0.83
2d	7:59 – 8:34 p. m.	35	2.87	4.92	129	0.81
3d	8:34 – 9:04 p. m.	30	2.46	4.92	121	0.81
4th	9:04 – 9:36 p. m.	32	2.75	5.16	130	0.82
5th	9:36 – 9:44 p. m.	8	0.61	4.58	127	
2d Prelim.	9:44 –10:03 p. m.	19	1.50	5.02	129	
1st	10:03 –10:37 p. m.	34	2.73	4.82	128	0.81
2d	10:37 –11:07 p. m.	30	2.23	4.46	129	0.85
3d	11:07 –11:38 p. m.	31	2.33	4.51	130	0.80
4th	11:38 p. m. 12:15 a. m.	37	3.12	5.06	130	0.87
	April 20					
5th	12:15 –12:50 a. m.	35	2.83	4.85	130	0.88
6th	12:50 – 1:22 a. m.	32	2.79	5.23	136	0.86
7th	1:22 – 1:59 a. m.	37	2.87	4.65	126	0.84
8th	1:59 – 2:32 a. m.	33	2.77	5.04	139	0.85
9th	2:32 – 3:24 a. m.	52	5.07	5.85	136	0.79
10th	3:24 – 3:58 a. m.	34	2.62	4.62	141	0.88
11th	3:58 – 4:27 a. m.	29	2.68	5.54	143	0.85
12th	4:27 – 5:16 a. m.	49	4.74	5.80	146	0.84
13th	5:16 – 5:52 a. m.	36	3.67	6.12	154	0.79
Preliminary	6:08 – 6:28 a. m.	20	2.21	6.63	153	
1st	6:28 – 7:01 a. m.	33	2.88	5.24	137	0.84
2d	7:01 – 7:50 a. m.	49	4.49	5.50	131	0.85
3d	7:50 – 8:19 a. m.	29	2.53	5.23	118	0.84
4th	8:19 – 8:56 a. m.	37	3.64	5.90	124	0.80
Preliminary	9:08 –10:07 a. m.	59	7.64	7.77	151	
1st	10:07 –10:34 a. m.	27	1.87	4.16	120	0.79
2d	10:34 –11:05 a. m.	31	2.85	5.52	122	0.88
3d	11:05 –11:32 a. m.	27	2.05	4.56	119	0.79
4th	11:32 a. m. 12:02 p. m.	30	2.76	5.52	130	0.81
5th	12:02 –12:28 p. m.	26	2.05	4.73	118	0.78
6th	12:28 –12:46 p. m.	18	1.92	6.40	148	0.80
Preliminary	12:57 – 2:12 p. m.	75	8.90	7.12	142	
Preliminary	2:12 – 3:48 p. m.	96	10.19	6.37	137	
Preliminary	4:00 – 4:22 p. m.	22	2.80	7.64	135	
1st	4:22 – 4:54 p. m.	32	4.26	7.99	148	0.85
2d	4:54 – 5:25 p. m.	31	3.80	7.35	142	0.81
3d	5:25 – 5:56 p. m.	31	2.40	4.65	114	0.76
4th	5:56 – 6:36 p. m.	40	3.64	5.46	126	0.79
5th	6:36 – 7:03 p. m.	27	2.08	4.62	122	1.02
Total.....		23 hr. 10 min.	130.44	....	...	0.82

An average of the figures of the "basal" and of the maximum metabolism of E. L. are given in Table 5.

TABLE 5.—AVERAGE OF THE "BASAL" AND MAXIMUM METABOLISM OF INFANT E. L.

	No. of Periods	Carbon Dioxid, Gm. per Hr., Average	Heat Computed (24 hr.) Calories			Average Pulse
			Total	Per Kg.	Per Sq. M. Lissauer	
"Basal" metabolism	12	4.15	285	57	944	117
Maximum metabolism	20	6.24	428	85	1417	135

The "basal" metabolism of 285 calories was increased 143 calories by muscular activity. This corresponds to an increase of 67 per cent.

The average figures of the "basal" and of the maximum metabolism of E. S. are given in Table 6.

TABLE 6.—AVERAGE OF THE "BASAL" AND MAXIMUM METABOLISM OF INFANT E. S.

	No. of Periods	Carbon Dioxid, Gm. per Hr., Average	Heat Computed (24 hr.) Calories			Average Pulse
			Total	Per Kg.	Per Sq. M. Lissauer	
"Basal" metabolism	18	4.75	338	59	1021	126
Maximum metabolism	12	6.75	481	84	1453	143

The "basal" metabolism of E. S. was increased 143 calories by muscular activity which corresponds to an increase of 70 per cent. This is very close to the average increase of 65 per cent. found in the new-born infant.[2]

Since the infants were removed from the chamber at regular intervals during the twenty-four hours for their usual nursings, the metabolism obviously could not be measured during that time, but an estimate of what it would have been is justifiable. Considerable muscular work is performed in nursing, and if the average maximum metabolism for each infant is taken to represent the metabolism during that time, it cannot be far from the truth. Baby E. L. was out of the chamber one hour and twenty-nine minutes, and Baby E. S., fifty minutes. The estimated metabolism for fifty minutes for Baby E. S. would be found as follows:

2. Benedict and Talbot: Physiology of the New-Born Infant, Carnegie Institution of Washington, Publication 233, p. 112, Table 17.

The average maximum total metabolism is 481 calories; divide this by twenty-four hours and it will give 20 calories, the amount produced in one hour; 50/60 of 20 = 17 calories, or the amount theoretically excreted during the fifty minutes that E. S. was out of the chamber.

Tables 7 and 8 give the total number of calories used up by Infants E. L. and E. S.

TABLE 7.—TOTAL NUMBER OF CALORIES USED BY INFANT E. L.

Period	Carbon Dioxid, Gm.	Respiratory Quotient	Heat Computed (24 hr.) Calories			Pulse Rate
			Total	Per Kg.	Per Sq. M. Lissauer	
Measured 22 hr., 31 min.	120.8	0.87	345	..	....	127
Estimated 1 hr., 29 min.	9.3	....	27			
Total.....	130	....	372	74	1232	

TABLE 8.—TOTAL NUMBER OF CALORIES USED BY INFANT E. S.

Period	Carbon Dioxid, Gm.	Respiratory Quotient	Heat Computed (24 hr.) Calories			Pulse Rate
			Total	Per Kg.	Per Sq. M. Lissauer	
Measured 23 hr., 10 min.	130.4	0.83	387	..	....	127
Estimated 50 min.	5.6	....	17			
Total.....	136.0	....	404	70	1232	

What is measured is the actual heat produced by these infants. There are, however, other ways in which energy may be lost from the body, such as the potential energy of the urine and feces. This energy which is lost must be supplied in the food. An estimate of this loss is, of course, open to many objections, and the figure given here will be modified by future investigations. Presumably the greatest single factor to take into consideration is the fat lost in the feces, which with the urea in the urine should not exceed 15 per cent. of the total measured metabolism in a normal infant.

When the factor for the food lost in the excreta has been added to the total, and that amount of food given to the infant, it should neither gain nor loose weight, but should remain in an equilibrium. Extra food must, therefore, be added so that the baby may grow. This figure is also difficult to estimate. Clinically, when infants are receiving only slightly more food than is necessary to maintain an equilibrium, they

gain very slowly in weight, whereas, if they are given more food they gain more rapidly. Rubner and Heubner's infants received a little less than 15 per cent. of the total measured calories for growth. If 20 per cent. is taken for the growth factor, it should give enough leeway for the infants to gain.

A rough estimate of the caloric requirements of a normal infant may be made by adding the calories used up by muscular activity to the basal metabolism. If the infant is very quiet, 15 per cent. should be added, if normally active 25 per cent., and if extremely active, about 40 per cent. To the result add 15 per cent. for energy lost in the excreta and 20 per cent. for growth. In the case of E. L. we know how many calories were actually used up in muscular exercise. Therefore, all that is necessary is to add the probable number of calories necessary to allow for growth and what is lost in the excreta. If 35 per cent. is added to the 74 calories per kilogram of body weight actually used by E. L., it is found that she needs about 100 calories per kilogram of body weight in her food. If the same thing is done for E. S., the food requirements are found to be about 94 calories per kilogram of body weight.

It is probable that infants fed on cow's milk, particularly on formulas containing large amounts of protein, will require even more food than infants fed on human milk, because the stimulating action of protein causes extra heat to be burned during digestion. The caloric requirements of normal infants obviously are not the same as those of the sick infant whose "basal" metabolism is higher per kilogram of body weight and who may use up additional energy because of increased restlessness from colic or discomfort, burn it up in fever, or may not absorb all the food given him, as happened in one infant who lost 20 per cent. of the food calories in the feces. Neither does it apply to the infant with a subnormal temperature, indicating depressed vital functions. These infants come under another category and require further study to answer many of the points now obscure.

SOME ANALYSES OF VEGETABLES SHOWING THE EFFECT OF THE METHOD OF COOKING*

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The addition of green vegetables to the dietary of young infants is becoming a common practice. It is generally believed that the value of this is due to the effect on the mineral metabolism. Infants who are fed for too long a time on an exclusive milk diet show anemia, late closure of the fontanel, delay in walking and general lack of activity. The secondary anemia is easily explained by the small amount of iron in cow's milk; after its dilution in milk formulas the amount of iron becomes almost negligible. Instead of making use of drugs to supply the needed iron, green vegetables have been fed to many children in the wards and the outpatient department of the Babies' Hospital. This plan has been followed with children as young as 6 or 7 months. It has been interesting to observe that infants thus fed show an earlier closure of the fontanel and generally greater activity than those without such additions to their diet.

How this beneficial effect is produced is a nutritional problem which is not within the scope of this paper. It has been variously explained. The mere addition of an increased quantity of salts may be advantageous. The particular combinations of the bases with the inorganic and organic acids present may provide the salts in an especially suitable form for use by the organism. A third view is that the value of the vegetables lies in a biologic or so-called vitamin effect. Since the general opinion is that the mineral content is the important factor, we have studied the subject from this point of view. We hoped to shed a little light on the question by determining the mineral metabolism of infants suffering with rickets and those showing delayed development, comparing their salt retention with and without vegetable additions to the diet.

The question immediately arose as to what was the actual mineral content of the vegetables as ordinarily prepared and administered.

* Submitted for publication May 28, 1917.
* From the Laboratories of the Rockefeller Institute for Medical Research and the Babies' Hospital.
* Read at the meeting of the American Pediatric Society, White Sulphur Springs, W. Va., May 28, 1917.

Abundant figures are available which show the total mineral content of the edible part of various vegetables. It is obvious, however, that the water used in cooking extracts more or less of the constituents and it is not a common practice to give this with the vegetable. Hence it is evident that the reported analyses are of no value in estimating the mineral content of vegetable additions to the diet of children. We therefore undertook a series of analyses of cooked vegetables, considering separately the solid portion ordinarily given as food and the water used in cooking.

At first the vegetables were cooked in the manner usual when preparing them as food for children; that is, by a very thorough boiling. After cooking, the vegetables were drained in a colander and the resulting solids and water were analyzed separately. The figures here reported are computed on the basis of 100 gm. of the edible portion of the uncooked vegetable (approximately a quarter of a pound).

TABLE 1.—CONTENT IN GRAMS OF SOLIDS OF VEGETABLES PREPARED BY BOILING

Vegetable	Minutes Boiled	Solids	Ash	CaO	MgO	P_2O_5	Cl	K_2O	Na_2O	H_2SO_4	Fe_2O_3	Total N	N. as Protein
Spinach	90	8.30	1.172	0.305	0.035	0.123	0.036	0.238	0.068	0.034	0.0090	0.497	3.10
New Zealand spinach	30	4.26	0.585	0.145	0.021	0.062	0.000	0.157	0.040	0.016	0.0154	0.236	1.48
Young carrots	30	6.31	0.408	0.039	0.014	0.043	0.023	0.181	0.038	0.022	0.0070	0.108	0.67
Onions	45	6.82	0.398	0.020	0.013	0.067	0.008	0.186	0.010	0.056	0.0026	0.189	1.18
String beans	150	5.31	0.371	0.070	0.030	0.063	0.045	0.123	0.011	.....	.....	0.190	1.19
Asparagus	30	4.59	0.370	0.038	0.021	0.101	0.024	0.174	0.001	0.025	Trace	0.283	1.77
Potatoes	30	20.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....

Table 1 shows the analyses of the solid portion of various vegetables boiled as described above.

Spinach shows the highest total salts, containing from two to three times as much ash as any of the other vegetables studied. This preponderance is due largely to calcium and phosphorus. The iron is highest in the New Zealand spinach, the ordinary spinach and carrots being next. The iron in onions is very low, while asparagus has only a trace. This table plainly shows that spinach is the most efficacious in supplying mineral addition.

New Zealand spinach is a comparative newcomer in the market. It does not belong to the same family as the ordinary spinach. It possesses the advantage of being available for a continuous supply throughout the summer, when ordinary spinach is not easily available. Although there is considerable waste in the preparation of New

Zealand spinach and it is rather a watery vegetable, it serves as a very satisfactory substitute for common spinach.

The analyses of the water drained from the cooked vegetables show very striking results. These are given in Table 2.

The excessive waste of salts if this water is discarded is very evident. It ranges from over a quarter of the total ash of onions to nearly

TABLE 2.—PERCENTAGE LOST IN WATER UNDER ORDINARY BOILING CONDITIONS

Vegetable	Minutes Boiled	Solids	Ash	CaO	MgO	P_2O_5	Cl	K_2O	Na_2O	H_2SO_4	Fe_2O_3	Total N
Spinach	90	32.2	45.2	Trace	61.5	48.2	71.1	64.8	61.1	57.2	28.2	23.1
New Zealand spinach	30	41.3	72.2	3.6	81.0	70.2	100.0	81.9	77.8	78.7	50.8	22.3
Young carrots	30	37.5	47.8	28.4	41.6	34.6	57.1	47.3	48.8	49.9	Trace	22.2
Onions	45	22.5	28.0	26.1	10.6	24.6	31.4	29.2	0	31.6	Trace	19.8
String beans	150	31.8	43.4	21.4	54.1	42.7	46.8	55.2	56.3	.....	.....	26.7
Asparagus	30	27.4	46.7	26.6	40.1	34.6	46.4	49.2	Trace	52.1	Trace	24.1
Potatoes	30	4.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	....

three quarters of that of New Zealand spinach. In the others the loss is about half the total. Calcium is the only constituent which is not seriously affected. The examination of potatoes showed so small a loss of total solids that the analyses were not carried through.

An attempt was next made to reduce the loss by boiling the vegetables for minimum time. A comparison of the effect of long and short boiling is given in Table 3.

TABLE 3.—COMPARISON OF PERCENTAGE LOST IN WATER WITH LONG AND SHORT BOILING

Vegetable	Minutes Boiled	Solids	Ash	CaO	MgO	P_2O_5	Cl	K_2O	Na_2O	H_2SO_4	Fe_2O_3	Total N
Spinach	90	32.2	45.2	Trace	61.5	48.2	71.1	64.8	61.1	57.2	28.2	23.1
Spinach	10	26.7	42.2	Trace	55.8	43.3	66.9	58.1	55.7	39.3	23.4	19.2
Beans	150	31.8	43.4	21.4	54.1	42.7	46.8	55.2	56.3	.....	.....	26.7
Beans	60	28.2	39.4	12.2	43.3	40.9	25.4	53.9	44.1	.....	.....	22.2

This table shows that the saving of salts by shorter boiling was insignificant. The only exceptions to this were the calcium and chlorid in the beans and the sulphate in spinach. Apparently the salts are lost early in the process of boiling.

Some modification of the method of cooking seemed to be necessary. Steaming was therefore tried, because it affords a method in

which the vegetables are held apart from the boiling water instead of soaking in it as in boiling. For this purpose a rice steamer was used. The vegetables are held in a tightly covered receptacle with a rather finely perforated bottom. This part fits closely on the top of the boiler which holds the water. Any type of steamer which holds the vegetables out of the water would undoubtedly serve as well.

Table 4 shows the results obtained by cooking the vegetables in this way.

TABLE 4.—COMPARISON OF PERCENTAGE LOST IN WATER BY STEAMING AND BY BOILING

Vegetable	Method of Cooking	Minutes Cooked	Solids	Ash	CaO	MgO	P_2O_5	Cl	K_2O	Na_2O	H_2SO_4	Fe_2O_3	Total N
Spinach.....	Boiling...	10	26.7	42.2	Trace	55.8	43.3	66.9	58.1	55.7	39.3	23.4	19.2
Spinach.....	Steaming.	15	17.5	25.5	(a)	(a)	19.7	(a)	34.8	51.2	(a)	(a)	(a)
New Zealand spinach.....	Boiling...	30	41.3	22.2	3.6	81.0	70.2	100.0	81.9	77.8	78.7	50.8	22.3
New Zealand spinach (b)....	Steaming.	30	5.2	15.3	7.9	22.3	29.8	7.3	19.4	50.5	21.3	0	0
Young carrots...	Boiling...	30	37.5	47.8	28.4	41.6	34.6	57.1	47.3	48.8	49.9	Trace	22.2
Young carrots...	Steaming.	15	8.8	13.6	(a)	(a)	10.7	(a)	10.0	14.3	(a)	Trace	(a)
Onions.....	Boiling...	45	22.5	28.0	26.1	10.6	24.6	31.4	29.2	0	31.6	Trace	19.8
Onions.....	Steaming.	30	20.4	25.5	27.9	7.9	21.6	28.2	26.6	0	23.2	Trace	18.7
Asparagus.....	Boiling...	30	27.4	46.7	26.6	40.1	34.6	46.4	49.2	Trace	52.1	Trace	24.1
Asparagus.....	Steaming.	30	8.5	15.2	(a)	(a)	11.5	(a)	15.8	0	(a)	(a)	(a)
Potatoes.....	Boiling...	30	4.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Potatoes.....	Steaming	30	1.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	....

(a) The amount of solids in the water from the steamed vegetables was too small to permit making all determinations.

(b) An analysis of the water from the steamed New Zealand spinach was not made. The percentages lost were estimated by assuming the total content of the water and the solid portion to be the same in the steamed as in the boiled.

It is obvious from an examination of Table 4 that steaming is by far the most economical method of cooking for preserving the salts. The remarkable saving of salts should be emphasized. In spinach the loss by steaming becomes about half what it was in boiling. In asparagus it is less than a third, and in carrots it is not even a fourth. The effect of steaming on the different constituents of the New Zealand spinach is more variable than in case of the other vegetables. Sodium is lost in a high degree even in steaming, but the saving in the other constituents, except calcium, is very striking. Onions, which lost the least in boiling, were the least affected by the changed method of cooking. It is a strange fact that there is a slightly greater loss of calcium by steaming than by boiling, but since the calcium loss is small in any case, this is of little importance.

For the benefit of those who may wish to feed the vegetables steamed, Table 5 is presented.

As in Table 1, the figures in Table 5 are computed on the basis of 100 gm. of the edible portion of the uncooked vegetable. When cooked, this amount yields approximately three tablespoonfuls of all but carrots, which furnish four.

TABLE 5.—CONTENT IN GRAMS OF SOLIDS OF VEGETABLES PREPARED BY STEAMING

Vegetable	Minutes St'm'd	Solids	Ash	CaO	MgO	P_2O_5	Cl	K_2O	Na_2O	H_2SO_4	Fe_2O_3	Total N	N. as Protein
Spinach (c)	15	7.12	1.047	0.100	0.080	0.079	0.032	0.341	0.047	0.052	0.041	0.421	2.63
New Zealand spinach	30	6.88	1.628	0.139	0.085	0.124	0.009	0.701	0.090	0.059	0.037	0.305	1.91
Young carrots	15	9.50	0.669	0.047	0.025	0.063	0.047	0.276	0.074	0.019	0.014	0.137	0.86
Onions	30	6.70	0.402	0.019	0.016	0.070	0.010	0.195	0.012	0.057	0.003	0.199	1.24
Asparagus	30	5.93	0.556	0.030	0.026	0.145	0.040	0.285	0.001	0.039	Trace	0.373	2.33
Potatoes	30	22.82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	....

(c) The spinach given here was a different variety from that used for the boiling experiment. This kind had thick, curly, dark green leaves and its toal mineral content was much lower.

A comparison of Tables 1 and 5 makes impressive the greater concentration in salts of vegetables prepared by steaming. For example, from the same amount of New Zealand spinach one can obtain approximately three times as much mineral matter by steaming as is available by boiling.

A table follows (Table 6) in which the approximate content of one tablespoonful of spinach and of carrots, cooked by steaming, has been estimated from Table 5.

TABLE 6.—APPROXIMATE CONTENT OF ONE TABLESPOONFUL OF STEAMED VEGETABLE

Vegetable	Solids	Ash	CaO	MgO	P_2O_5	Cl	K_2O	Na_2O	H_2SO_4	Fe_2O_3	Total N	N. as Protein
Spinach	2.37	0.349	0.033	0.030	0.026	0.011	0.114	0.016	0.017	0.014	0.140	0.88
Young-carrots	2.40	0.167	0.012	0.006	0.016	0.012	0.069	0.018	0.005	0.004	0.034	0.21

If a steamer is not available, the cooking may be done in a double boiler. The vegetable should be prepared as usual, drained after washing and placed with no additional water in the inner boiler. Spinach requires about thirty minutes to cook in this manner. Table 7 gives a comparison of the result of this method of cooking with that by steaming.

It will be seen that there is very little choice between the two methods as regards the saving of salts.

TABLE 7.—Comparison of Spinach Steamed and That Cooked in Double Boiler

	Method of Cooking	Solids	Ash	CaO	MgO	P_2O_5	Cl	K_2O	Na_2O	H_2SO_4	Fe_2O_3	Total N	N. as Protein
Content of solid portion from 100 gm. of spinach	Steaming	7.12	1.047	0.100	0.089	0.079	0.032	0.341	0.047	0.052	0.041	0.421	2.63
	Double boiler	8.03	0.997	0.166	0.049	0.107	0.024	0.243	0.114	.....	.....	0.574	3.59
Percentage lost in water of cooking	Steaming	17.5	25.5	(a)	(a)	19.7	(a)	34.8	51.2	(a)	(a)	(a)	....
	Double boiler	15.5	25.6	4.5	33.3	25.6	(a)	34.7	30.3	(a)	30.8	(a)	....

(a) The amount of solids in the water was too small to permit making all determinations.

Early in the paper reference was made to the possible importance of the combinations of bases with inorganic and organic acids. A study of the tables shows a great preponderance of bases over inorganic acids. This must mean that a considerable proportion of the bases are held as salts of organic acids. It is generally believed that such compounds are more assimilable than inorganic salts. Hence there would appear to be some ground for the theory that the beneficial effect of vegetable feeding is at least partly due to the character of the combinations of bases and acids.

Some metabolism experiments on the effect of vegetable addition to the food on the mineral balance are under way. With one child, somewhat rachitic and very backward in development, an improved balance was obtained after spinach had been added to a food otherwise considerably reduced. We hope to report these results, with those from other observations, later.

The methods used in obtaining the results reported in this paper are those previously used in work reported from these laboratories.[1] The iron was determined gravimetrically as iron phosphate.

CONCLUSIONS

1. A large proportion of the mineral content of most vegetables is lost in the water used in cooking by boiling.

2. This loss is only slightly reduced by making the time of boiling a minimum.

3. A very great saving in mineral content may be effected by using the method of steaming.

4. Spinach is the best vegetable to provide a salt addition to the diet.

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1. Holt, L. E., Courtney, A. M., and Fales, H.: Chemical Composition of Diarrheal as Compared with Normal Stools in Infants, Am. Jour. Dis. Child., 1915, **9**, 213.

ENLARGEMENT OF THE THYMUS TREATED BY THE ROENTGEN RAY*

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CINCINNATI

The purpose of this paper is to emphasize again three distinct facts with reference to enlargement of the thymus: (1) The condition is much commoner than is ordinarily supposed. (2) The diagnosis can be made definitely by means of simple physical examination and the Roentgen ray. (3) In the Roentgen ray we possess a therapeutic agent, which, in and of itself, will effect a cure in the vast majority of cases.

1. *Occurrence.*—According to some clinicians, enlargement of the thymus is supposed to be a rather rare condition. Those of us who have been particularly interested in the condition have been able to prove the fallacy of this view. The condition is in reality quite common. It is rather astonishing to note how frequently it is to be found if it be systematically searched for. As illustration of this I may refer to the paper of Dr. J. E. Benjamin, read before the Academy of Medicine of Cincinnati and now in press. In his individual service in the children's out-patient clinic (University of Cincinnati), Dr. Benjamin had 225 new cases in a year's time. Of these, nineteen showed indisputable evidence of enlarged thymus (8.4 per cent.). No other physician in the out-patient department found so many cases, because no other physician examined his patients so carefully with reference to this particular condition.

While very little is known about the etiology of enlarged thymus, certain facts have recently come to light in our studies. Quite a few of our cases have occurred in babies suffering from congenital syphilis. At present no conclusions can be drawn from this observation.

A distinct familial tendency has also been noted. In our recent cases four families had more than one child affected. Two pairs of twins came under observation, all four of the infants having enlarged thymus.

We have also noted an apparent relationship of hypertrophic stenosis of the pylorus and enlarged thymus. Dr. Dudley W. Palmer has recently reported a series of fourteen cases of congenital pyloric stenosis, of which seven had enlarged thymus. I have seen two additional cases occurring in the practice of Dr. Rachford.

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* Submitted for publication May 28, 1917.
* Read at the meeting of the American Pediatric Society, White Sulphur Springs, W. Va., May 28, 1917.

2. *Diagnosis.*—At the onset it should be borne in mind that some cases of enlarged thymus run a symptomless course. These latent cases are discovered only as the result of careful routine examination. Sudden death as the result of trauma, anesthesia or intercurrent affection occurs not infrequently in these cases. As a matter of fact, intercurrent affections frequently light up pressure effects of an enlarged thymus hitherto unsuspected. Thus, in a former paper I referred to a child, who had apparently been perfectly normal, brought to the hospital with typical thymic asthma after a severe attack of whooping-cough. Postmortem, a hyperplastic thymus was found.

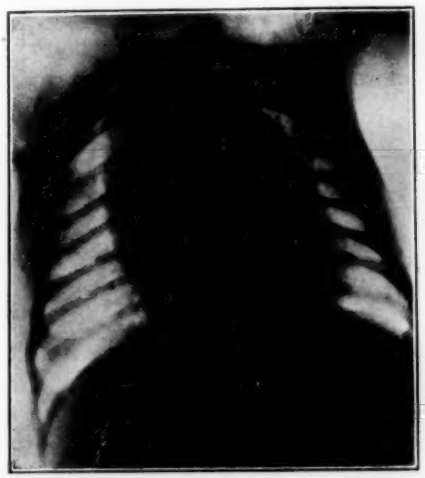

Figure 1

Figure 1a

Fig. 1.—F. E. before treatment, 3/12/17.
Fig. 1a.—F. E. after three treatments, 3/29/17.

There are three definite symptoms of enlarged thymus which are present singly or together. These are dyspnea, continuous or remittent, suffocative attacks, with cyanosis and stridor.

The dyspnea may be either permanent or intermittent. The permanent type is the more common. The respiratory difficulty increases until the child has a suffocative attack, accompanied by intense cyanosis. The attacks are repeated with greater or less frequency, and death may occur during one of them. Between attacks the dyspnea is continuous.

In the intermittent forms, children apparently quite normal and usually several months of age, are suddenly seized with suffocative attacks, accompanied by cyanosis — usually associated with convulsive movements of the extremities — followed after a few moments by a

return to an apparently normal state. The intervals between the attacks, at first considerable, tend to become constantly shorter. Variations and gradations of the two forms are common. Nocturnal cough, usually dry and hacking, is a frequent symptom in both forms.

Stridor, when present, is usually inspiratory. The frequent association of enlarged thymus and congenital stridor does not admit of question. But not all cases of congenital stridor are due to enlarged thymus, as was supposed by Hochsinger. Reflund and Koplik have shown that some cases are due to malformation of the epiglottis, and Lees and Thomson point out that in some cases the stridor is due to incoordination of the vocal cords, the result of muscular imbalance.

The diagnostic physical signs of greatest importance are these: Detection of a bulging mass in the jugulum (more often absent than present); enlargement of the area of normal thymus dulness on per-

Figure 2

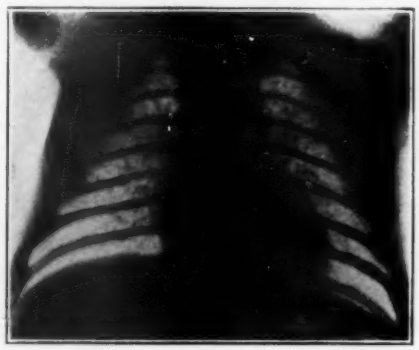

Figure 2a

Fig. 2.—McN. before treatment, 3/25/17.
Fig. 2a.—McN. after three treatments, 4/17/17.

cussion. In young children there is a definite form of thymus dulness in the shape of an irregular triangle or truncated cone whose base is the sternoclavicular junction and whose apex is the second rib. Laterally, the dulness extends but very slightly beyond the sternum. Dulness beyond the sternal margins, especially dulness continuous with the area of heart dulness, is always very suggestive of enlarged thymus. The percussion of the area of thymic dulness is not difficult if one uses very light, or, at times, threshhold percussion. The claim of Boggs that the thymus dulness is movable, depending on whether the neck is flexed or extended, we have not been able to substantiate.

Definite information as to the existence of the enlargement of the thymus is afforded by the Roentgen ray. Certain requirements in the taking of these pictures must, however, be met. Dr. Sidney Lange of

Cincinnati has worked out a very careful technic. His procedure is here quoted in detail.

The child to be radiographed must be placed flat on the back. There must be no tilting to either side. If there is the slightest lateral tilting there is produced on the Roentgen-ray plate an asymmetry of the two halves of the chest and a "ffopping" or displacement of the mediastinal and heart shadows to one or the other side. Roentgen-ray plates produced under such conditions are usually valueless, as they can not be accurately interpreted. It is not always easy to place very young infants symmetrically on their backs, but repeated trials must be made until a plate is produced which shows the chest areas, that is, the distances from the midline of the spine to axillary borders of the ribs, to be equal on right and left sides. Under these conditions, enlargements of the upper mediastinal shadow, whether to the right or to the left of the midline, can be readily recognized.

It is essential in the making of these roentgenograms of very young children that the exposure be almost instantaneous. The reasons are obvious.

Figure 3

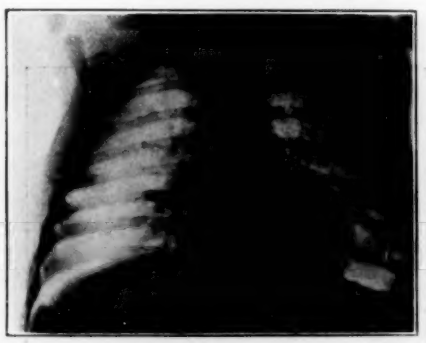

Figure 3a

Fig. 3.—E. H. before treatment, 1/19/17.
Fig. 3a.—E. H. after three treatments, 2/6/17.

In the series here presented the time of exposure varied from one-sixtieth to one-thirtieth of a second. Even with such short exposures it is not always possible to secure absolutely sharp contours on the plates. If the time exceeds one-thirtieth of a second there results an amount of blurring.

A very soft Roentgen-ray tube should be used for this work, as the delicate thymus tissue will fail to cast a shadow on the Roentgen-ray plate if the quality of the Roentgen ray employed be too hard or penetrating.

The normal Roentgen-ray shadow is a median one, which normally rests on and is continuous with the heart shadow. Marked enlargement of this shadow, especially marked lateral enlargement, is characteristic of hypertrophied thymus. There is no difficulty, as a rule, in differentiating the shadow produced by enlarged thymus from that produced by congenital heart lesions or caseous lymph nodes. In a careful study of the interpretation of the thorax roentgenogram in the nursling, Benjamin and Goett point out that a broadening of the

shadow to the right may at times be due to large vessels, especially the vena cava superior. But, as they note, this cannot hold good when the larger part of the shadow falls to the left of the vertebral column.

In our work there has been no difficulty in eliminating this source of error in diagnosis.

Enlarged bronchial glands give an extra median shadow separate from the heart shadow and not connected with it. Ferrand, and Chatelin and Myer have also called attention to this point.

It would appear certain that enlargement of the thymus may exist, without the coexistence of the constitutional syndrome described by Paltauf as status lymphaticus.

This has been demonstrated repeatedly in our studies and is of importance, because children with enlarged thymus treated with the Roentgen ray get well and remain well, showing no further constitutional abnormality.

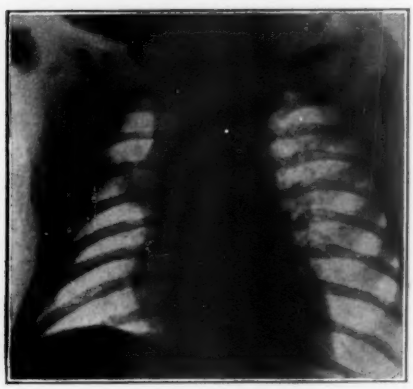

Figure 4

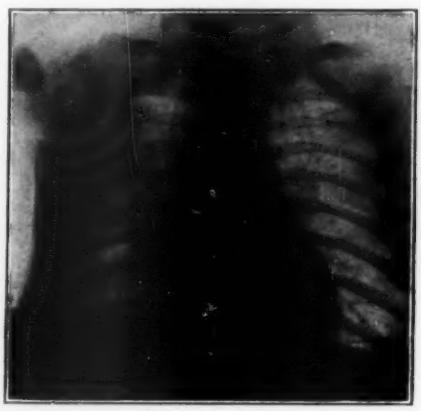

Figure 4a

Fig. 4.—O. before treatment, 11/9/16.
Fig. 4a.—O. after three treatments, 11/28/16.

Finally, with reference to diagnosis, it should be said that in doubtful cases where symptoms of thymic asthma appear without clearly demonstrable physical signs, the Roentgen-ray treatment given as a therapeutic test will often clear the diagnosis.

3. *Treatment.* — The treatment of enlarged thymus is in reality remarkably simple. The results of thymectomy may aptly be summarized in one sentence quoted from one of its advocates (Parker). Of the fifty patients operated on, seventeen died, a mortality of 33⅓ per cent. In the Roentgen ray we have a therapeutic agent at once safe and remarkably efficacious. Our series in Cincinnati now exceeds 100 cases, with four deaths.

The technic of the treatment as worked out by Lange is as follows: A Coolidge tube, backing up a 9½-inch spark, was employed. The rays were filtered through 4 mm. of aluminum and a piece of thick leather. The target skin distance was approximately 9 inches. The routine exposure was 25 milliampereminutes. In mild cases a single dose given over the anterior surface of the chest proved sufficient. In more urgent cases 50 milliampereminutes were administered at the first treatment, 25 anteriorly and 25 posteriorly. During the treatment the child was kept quiet by four sandbags, one placed across each arm and one across each leg. The interval between treatments was usually one week unless the urgency of symptoms suggested more frequent applications. The treatments have proved entirely harmless to young children, and if the symptoms are very urgent, a second dose may be given within a day or two after the first. In order to get results it is essen-

Figure 5

Figure 5a

Fig. 5.—M. E. before treatment, 3/12/17.
Fig. 5a.—M. E. after three treatments, 3/29/17.

tial that the treatments be comparatively heavy and that they be repeated at sufficiently short intervals. The failure to administer full doses and to repeat them promptly has in very urgent cases led to fatalities under Roentgen-ray treatment. Such a distressing occurrence is, fortunately, uncommon, but when it does happen it casts a doubt on the diagnosis or on the efficiency of the Roentgen-ray therapy. To guard against sudden deaths before the full destructive effect of the Roentgen ray on the thymus gland has been elicited, all patients with urgent symptoms should be kept under close observation and the Roentgen-ray treatments should be pushed boldly.

In the average case, improvement of symptoms has been noted within twenty-four to forty-eight hours after the treatment. It is possible, however, as shown by animal experimentation, to elicit changes

in the thymus gland within eight hours after the exposure. Therefore, the most urgent cases can be saved by this treatment.

The pictures here presented are taken from our patients at the Cincinnati General Hospital.

The thymus plates are shown in pairs for each case. First before treatment; second after treatment, with dates.

4 West Seventh Street.

THE VALUE OF THE VON PIRQUET TEST AS CONTROLLED BY NECROPSY FINDINGS*

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The object of this paper is to report the results of a study of the von Pirquet cutaneous test for tuberculosis on a series of children who have died and on whom careful necropsies have been performed. It is felt that in this way alone a conclusive judgment as to the value of the von Pirquet reaction in making a positive diagnosis of the presence or absence of tuberculosis can be acquired, for postmortem examination offers the only absolute verification of the diagnosis of tuberculosis.

Many investigations of this reaction have been made in this country on children from infancy through school age, in which the results of the test, whether positive or negative, have been confirmed by painstaking physical examination, or by means of the Roentgen ray — very exceptionally by the determination of tubercle bacilli. The discovery of tubercle bacilli, of course, must be accepted as indubitable evidence of the presence of tuberculous infection, but the examination of the chest by the most refined methods at our disposal assisted by Roentgen rays is still a gross and unsatisfactory method of establishing the absence or presence of tuberculosis in doubtful cases, and therefore cannot be used to verify with absolute certainty the value of the von Pirquet reaction. Confirmatory evidence of the reliability of this test has been furnished by a number of writers who have shown that the percentage of positive reactions in children increases with their age; that the danger from spreading and fatal tuberculosis is in inverse ratio to the age of the patient, and that tuberculous infection under two years is rarely recovered from.

Thus Rogers,[1] who followed fifty of the sixty-nine children with positive von Pirquet reactions after their discharge from the Massachusetts General Hospital, found that of the seventeen under 2 years of age, 65 per cent. died, whereas of the thirty-three over 2 years, but 21 per cent. succumbed in from one to four years.

The comparative infrequency of tuberculosis among young infants was shown by Voronin,[2] who examined 140 infants between 2 days

* Submitted for publication May 28, 1917.
* Read at the meeting of the American Pediatric Society, White Sulphur Springs, W. Va., May 28, 1917.

1. Rogers, O. F.: A Study of Children with Positive Skin Tuberculin Reactions, Boston Med. and Surg. Jour., 1915, **172,** 161.

2. Voronin, M. S.: Tuberculin Skin Reactions, Russk. Vrach., 1915, **14,** 12, 280.

and 4 months of age, and obtained only two positive von Pirquet reactions.

Brown[3] performed the test on 650 children, 164 of whom were under 6 months, and of these, twenty reacted positively and all but one died.

Veeder and Johnston[4] as the result of von Pirquet tests on a large number of schoolchildren in St. Louis, between 10 and 14 years, found that 44 per cent. reacted positively to the von Pirquet test, as compared to 90 per cent. found by Hamburger in a similar investigation among children in Vienna. Veeder's results have been confirmed in many American cities and would indicate that tuberculosis, though all too prevalent, is less widespread in America than in most of the cities of Europe. This is probably due to the more favorable hygienic surroundings in this country, as Keifetz[5] has found that the positive von Pirquet reaction was obtained twice as frequently among children living among unfavorable surroundings as among those living in an environment described as favorable.

Von Pirquet's[6] report on the value of the cutaneous test for tuberculosis in children, is based on the examination of about 2,000 children. Of these, 200 died and came to necropsy. Of the fatal cases, 109 had no tuberculous lesions, while in eighty-nine, foci of tuberculosis were found, and two had doubtful lesions. The 109 children found at necropsy to be free from tuberculosis had negative skin reactions. Of the eighty-nine cases shown to have tuberculous lesions at necropsy, sixty had positive von Pirquet tests and twenty-nine had negative reactions. In the negative cases the reaction was made during measles, or on patients extremely ill with spreading or advanced lesions of tuberculosis.

The present study is based on investigation of the fatal cases that have come to necropsy from the Harriet Lane Home, of the Johns Hopkins Hospital, service of Dr. Howland, to whom I am indebted for the use of his material, from November, 1912, to April, 1917. In this time there were approximately 2,940 cases admitted to the wards, with 750 deaths. Of this number, careful necropsies were performed on 324 infants and children, from birth to 12 years of age.

These necropsy cases have been analyzed with reference to the von Pirquet reaction. Sixty-eight cases were found to have tuberculous lesions on postmortem examination, that is, about 20 per cent. of

3. Brown, A.: Am. Jour. Obst., 1913, **68,** 377.

4. Veeder, B. S., and Johnston, M. R.: The Frequency of Infection with the Tubercle Bacilli in Childhood, AM. JOUR. DIS. CHILD., 1915, **9,** 478.

5. Keifetz, M. N.: Cutaneous Tuberculin Test in School Children, Jour. Am. Med. Assn., 1915, **65,** 1412.

6. Von Pirquet, C.: Summarized in Cleveland Med. Jour., 1908, **7,** 585.

the fatal cases examined after death. Two hundred and fifty-six, or 80 per cent., were found at postmortem examination to be free from tuberculosis.

This incidence of tuberculosis in infancy and childhood agrees with the results of Veeder's investigations and is much smaller than is reported in European centers. As has been repeatedly found, the number of tuberculous cases increased rapidly with the age of the patient.

The tuberculous and the nontuberculous cases have been tabulated according to age and color and with reference to the von Pirquet reaction.

TABLE 1.—Tuberculous Cases at Necropsy

White			Black			Totals		
						White	Black	White and Black
Under 6 mo.								
+	—	Not made	+	—	Not made			
2			2	2	1	2	5	7
7 to 12 mo.								
5	1		4	1	2	6	7	13
13 to 24 mo.								
4	1		4	3		5	7	12
Over 2 yr.								
7	4		17	4	4	11	25	36
Total								
+	—	Not made	+	—	Not made			
18	6	0	27	10	7	24	44	68

This test was made, where performed at all, as a routine measure by the ward intern. Koch's old tuberculin, undiluted, was used and the scarification done by the borer devised by von Pirquet. Readings were made in twenty-four and forty-eight hours. Of the 256 cases having no tuberculous lesions at necropsy, the test was made in 172 instances. It was never positive, but negative without exception.

On the original inspection of this series, there were four cases thought to be positive, but in carefully reviewing the histories it was found that in three instances, although the first test had been doubtful, a second confirmative test was negative, and in the fourth case, a patch of fibrous pleurisy, probably tuberculous, accounted for the postive skin reaction.

It should be emphasized that no doubtful cases should be called positive, but the test should be repeated; and only those called positive in which there is a marked contrast between the tuberculin treated areas and the control site. This result seems to furnish most reliable confirmatory evidence among American children that a properly performed von Pirquet reaction which is constantly negative precludes the possibility of tuberculous infection, except in extremely ill children.

Of the sixty-eight cases in which tuberculous lesions were found at necropsy, the von Pirquet reaction was made in sixty-one; of these, it resulted positively in forty-five cases and negative in sixteen. The negative cases were carefully analyzed. In twelve instances the

TABLE 2.—NON-TUBERCULOUS CASES AT NECROPSY

White			Black			Totals		
						White	Black	White and Black
Under 6 mo.								
+	—	Not made	+	—	Not made			
0	41	25		34	27	66	61	127
7 to 12 mo.								
0	21	10	0	17	6	31	23	54
13 to 24 mo.								
0	19	3	0	15	3	22	18	40
Over 2 yr.								
0	15	8	0	10	2	23	12	35
Total								
+	—	Not made	+	—	Not made			
0	96	46	0	76	38	142	114	256

patients were suffering from rapidly advancing widespread miliary tuberculosis, in two instances from tuberculous meningitis, in two from pulmonary tuberculosis of advanced stage with cavity formation, and in one instance from tuberculous peritonitis. In all instances the test had been made from a week to a few days before death, usually several weeks after the onset of illness.

It can be fairly concluded, therefore, from our figures, that as asserted by von Pirquet and repeatedly confirmed by other investigators, that a positive cutaneous test indicates the presence of a tuberculous lesion, but that a negative test in patients extremely ill, overwhelmed by the toxin of tuberculosis, especially in those suffering from miliary tuberculosis, may frequently fail to react positively. In

other words, a negative test, except in extremely ill patients in which the physical examination would probably determine the presence of tuberculosis, usually indicates the absence of tuberculous lesions, whereas a positive reaction in every instance shows the presence of tuberculosis. None of the patients in our series had measles.

The tabulation of the tuberculous cases shows that forty-four of the sixty-eight cases are colored, and twenty-four white; and of the seven fatal cases under 6 months, five are colored, and two white. These results would strengthen the view that tuberculosis is much more prevalent among the black than among the white races, in proportion to their population, and that the tuberculous infection occurs at an earlier period of life in the black.

It may be concluded from these results here reported that the cutaneous test with tuberculin, as described by von Pirquet, is a most reliable aid in the detection of tuberculosis in children; that a positive reaction indicates invariably a tuberculous focus in the body; and that a persistently negative reaction establishes the fact that there is no tuberculous lesion except in those extremely ill patients where the presence of tuberculosis can be readily established by physical examination.

INTRAVENOUS GLUCOSE INJECTIONS IN INFANCY*

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BOSTON

The principal difficulty attending intravenous injections and transfusion in young infants has always been a technical one due to the extremely small size of the veins. The suggestion of Helmholtz, that in hemorrhagic disease of the newborn transfusion could be more easily performed by using the longitudinal sinus, appeared to be of the greatest importance in this connection. The longitudinal sinus in the infant is a large vein easily accessible through the open fontanel. If the employment of this route in performing transfusion avoids the principal technical difficulty, it is available not only for transfusion in hemorrhagic disease of the newborn, but also for the giving of intravenous injections and medication. That certain forms of medication, as well as the giving of fluid for the purpose of stimulation or of supplying loss to the blood, are best given directly into the blood itself rather than by mouth or by the subcutaneous route, has long been recognized. This is particularly true, when it is desired to give normal salt solution or circulatory stimulants in certain cases in infants in which the condition is such that absorption from the skin takes place with great difficulty. Such a condition is seen in many cases of extreme atrophy and inanition.

At the Infants' Hospital we have adopted the use of the longitudinal sinus for obtaining blood for the Wassermann reaction and for giving intravenous injections. The technic has proved to be extremely simple and apparently entirely free from danger, except perhaps when salvarsan is used. We have used the longitudinal sinus for the giving of normal salt solution, of sodium bicarbonate in acidosis, of antitoxin in diphtheria, of circulatory stimulant drugs and of solutions of glucose. It is the glucose injections which are to be considered in this paper.

The cases in which the intravenous injection of glucose was used were all of approximately the same type. They were cases of a condition well known to all pediatrists, showing extreme atrophy and inanition produced by various forms of gastro-intestinal disease. Such cases are commonly admitted to the hospital in a moribund condition, especially in the summer and autumn months. Other cases are in less immediately serious condition when first admitted, but go down hill rapidly in spite of all our available therapeutic resources. In the treat-

* Submitted for publication May 28, 1917.
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ment of these cases, in addition to the regular dietetic treatment of the underlying gastro-intestinal disability, we have such measures as the checking of excessive watery diarrhea with loss of salts by means of opium, the counteracting of a relative acidosis by the giving of sodium bicarbonate, and the giving of fluid by rectum or subcutaneously to supply loss and as a circulatory stimulant. All the cases reported in the present series were of infants who were either admitted to the hospital in an actually moribund condition, or, who after admission become steadily worse under all the ordinary methods of treatment.

The theoretical basis for the use of intravenous glucose injections in such cases is that apparently the vicious circle produced by gastro-intestinal disorder has become so extreme that the digestion and absorption of sufficient food to furnish the energy requirement of the body is impossible. Necropsies in such cases seldom reveal lesions of a character sufficiently pronounced to be considered the cause of death. We can only assume that death is produced either by lack of fuel, or by the accumulation of the toxic products of a metabolism disordered by the lack of fuel. Glucose is the only food substance which exists outside the body in the same form in which it circulates in the blood and is utilized by the tissues. All other food substances must go through the complicated processes of digestion and alimentary absorption before they can be used. Consequently, it seemed that the injections of glucose directly into the blood in these cases might, through a temporary supply of even a small quantity of fuel, break the vicious circle for a length of time sufficient to permit improvement of the condition to take place.

TECHNIC

The technic which has been used is very simple. A syringe sufficiently large to hold the entire quantity of fluid to be given is connected with the needle by means of flexible rubber tubing. There is a glass window in the tubing just above the needle. The needle is of a small size, such as is used for lumbar puncture in infants, slightly larger than an antitoxin needle. The entire apparatus is sterilized, and the syringe is filled with a sterile 5 per cent. glucose solution. After expulsion of any air which may be in the tube, the needle is entered at the posterior angle of the fontanel. Three persons are required to give the injection: one to steady the infant's head, one to manipulate the needle, and one to manage the syringe. The entrance of the needle into the sinus is accompanied by a sudden lessening of resistance. The piston of the syringe is then slightly and slowly withdrawn until blood appears at the glass window. As soon as the appearance of blood shows that the needle is actually in the sinus, the movement is reversed and the glucose is injected very slowly, the assistant holding the needle firmly in place. We have adopted the use of a syringe rather than the use of the gravity method because with the syringe and glass window one can make sure that the injection is actually going into the sinus. We have found no objection to the use of the syringe if the injection is given very slowly. A sign of too rapid injection of the fluid is distention of the superficial veins of the scalp. No accidents or unfavorable effects which could in any way be attributed to the intravenous injections have been observed with glucose solutions.

In determining the quantity of glucose to be injected, I rather arbitrarily adopted a 5 per cent. solution. I am inclined to think, however, that I shall try somewhat stronger solutions in the future. The quantity of the solution to be injected depends on the quantity of fluid which it is safe to inject into the infant's circulation. This, of course, is not definitely known, and I was obliged to adopt an arbitrary rule. We began with a quantity of fluid approximately equal to one fourth of the estimated blood volume of the infant. As this quantity of fluid appeared to produce no bad results of any kind, it was adopted as the standard for intravenous injections. The blood volume is estimated at approximately one fifteenth of the body weight, and therefore in choosing the quantity of glucose solution for intravenous administration to a baby, one sixtieth of the body weight is taken. The quantity of glucose given, therefore, varies with the body weight of the infant. With 5 per cent. solutions, it lies between 1 gm. as a minimum, which would be contained in 22 c.c. of fluid, and would be suitable for a baby weighing 1,320 gm., and 12 gm. of glucose, which would be contained in 240 c.c. of fluid, and would be suitable for a baby weighing 14,400 gm.

RESULTS

In eighteen cases the records are sufficiently complete to make them available for the purposes of this report. I do not wish to imply, however, that these cases are presented in statistical form as proof of benefit from the injections. Clinical evidence of improvement with any therapeutic procedure of this kind is very uncertain and can never be accepted as proof. Nevertheless, in some of the cases the improvement which followed the injections was so immediate and so striking that it seems to me there is a possibility at least that the injections produced a good effect. It must be remembered that all the cases were either actually moribund or were of a type in which all other measures had failed, and in which a fatal ending seemed imminent. Of the eighteen cases in which this treatment was used, thirteen died and five recovered. After the injections, seven cases showed no improvement, five cases showed a slight temporary improvement, and six cases showed a striking improvement immediately following the injections. There is no evidence that the improvement, even if it was due to the intravenous injection, was caused by the glucose. The giving of fluid into the circulation in cases of this character is a therapeutic procedure of known value, and it is quite possible that the apparent improvement was due to the fluid given and not to the glucose.

I have not on record a sufficient number of control cases in which normal saline solution was given intravenously instead of glucose to present any evidence on this point. Even if I had such a series of control cases, the evidence would not be of much value in pointing to the glucose as the cause of improvement. There is, however, sufficient possibility of the improvement being due to this therapeutic procedure to warrant its further trial.

There is certainly a possibility of the glucose being of value if it is actually utilized for purposes of energy production. Evidence on this

TABLE.—Results of Urinary Examination

Case No.	Dates of Injection	Quantity of Glucose Given (Gm.)	Quantity of Glucose Eliminated (Gm.)
1	October 15	1.5	0.074
	October 16	3	0.220 +
	Total	4.5	0.294 +
2	October 12	0.75	0
3	October 2	6	0
4	October 25	3	0.068
	October 27	3	0.116 +
	Total	6	0.184 +
5	October 31	4.5	?
6	September 23	3	0
7	September 23	3	0.112 +
8	September 16	3	0
9	November 4	2.25	Slight trace
10	September 14	1.5	0
	September 16	2.25	Slight trace
	October 2	1.875	0
	October 17	2.25	Slight trace
11	October 29	3	0.086
12	August 28	3	0
13	September 27	4.5	0.047 +
14	September 14	3	0.08
	September 16	3	Slight trace
	Total	6	0.08
15	September 11	3	0
	September 12	3	0
	September 15	3	0
	September 16	3	0
	September 17	3	0
	September 18	3	0
	Total	18	0
16	August 28	3	Slight trace
17	July 12	3	?
18	July 1	1.5	0

point can be obtained from the examination of the urine because glucose in the blood not utilized is excreted through this route. Efforts were made in all the cases of the series to determine what proportion of the glucose given by intravenous injection was not utilized and was excreted by the kidneys. For this purpose, all the urine passed after the injection was collected for twenty-four hours, or until it was sugar-free. A quantitative estimation was made of the sugar excreted. For the quantitative tests, Benedict's solution was used. The table shows the results of the urinary examination in these cases. A question mark in the column showing the quantity of glucose eliminated means that the patient died before any urinary examination could be made. The plus sign after the figure in the same column shows that the patient died before the urine became sugar-free and that, therefore, the figure does not represent the total quantity eliminated. The term "slight trace" in this column means that the urine gave a qualitative reaction to sugar with the most delicate reagent (Folin's), but that the amount of sugar was too small to measure by the quantitative test.

It will be seen from the table that in the great majority of instances either no sugar was eliminated in the urine after the intravenous injections, or else there was only a slight trace. Only in six instances was a measurable quantity of glucose eliminated, the maximum quantity eliminated in any instance being 220 mg., or only 0.66 per cent. of the quantity of glucose injected into the blood. These results appear to prove that whether or not the glucose produced a favorable effect, it was at least utilized by the child's metabolism. With such utilization there is certainly a possibility of a favorable effect even from the small quantities of glucose which were given.

The table shows that only one injection was given in the majority of the cases in the series. This is because so many of the patients showed no notable improvement or died soon after the giving of the injections. In five cases more than one injection was given, these corresponding to three of the cases in which the patients eventually recovered and to two of the cases in which the patients showed a marked improvement but died at a subsequent period. In Case No. 15, six daily injections of 3 gm. of glucose each were given. In this case, it seemed to us that the patient was practically kept alive by the glucose injections, and that recovery was due to this method of treatment. This patient eliminated no sugar in the urine at any time.

The diseased condition which these cases represent is very serious and fatal, and it seems to me that in its treatment we have need of every possible therapeutic resource. It is my hope that further trial will either add to the slight evidence which I have presented as pointing to the possible value of intravenous glucose injections, or will conclusively disprove the value of this therapeutic procedure.

POSTOPERATIVE ACID INTOXICATION *

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For the past twenty years or more there has been an increasing literature reporting serious and fatal illness in children following surgical operation, the illness apparently having no direct relation to the immediate effects of the anesthetic or the operation. This condition, characterized by vomiting, thirst, flushed face, somnolence and restlessness, and, in the more severe cases, by delirium, coma and death, has been known by a variety of names, but the general idea pervading the literature and expressed in the various names has been that it is an acid intoxication closely associated with or caused by the acetone bodies. A few authors have taken exception to this view on the ground that the accumulation of acids in the body in the condition described has never been proved, though no other evidence is offered in their support. Though there is a large and ever-increasing number of articles dealing with the subject, there remains an absence of rather essential data for the better understanding of this phenomenon. It was with the hope of answering some of the unsettled questions that the work of this paper was undertaken. It might be added that at the beginning of the observations a strong prejudice toward the acetone body causation of the condition was entertained.

Material Studied. — The points to be emphasized here are based largely on the study of twenty-two operative cases. These were taken consecutively and not selected in any way, though it so happened that among them there were no cases showing the symptoms above described, and the group also happens to represent very little emergency surgery. All patients were anesthetized with ether by the same professional anesthetist. In these twenty-two cases the urine was examined in twenty-four-hour periods before and after operation, and the blood before and at frequent intervals after operation, the observations being continued for at least forty-eight hours after operation, and when indicated, for seventy-two hours. In the urine were determined the acetone bodies and the ammonia coefficient, and in the blood the acetone bodies and the plasma carbonate.

* Submitted for publication May 25, 1917.

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The acetone bodies of the urine were determined by the iodimetric method of Messinger and the oxidation method of Shaffer.[1] The nitrogen of the urine was determined by the micro-methods of Folin.[2] The acetone bodies of the blood were determined by the method of Marriott[3] and the plasma carbonate by the method of Van Slyke.[4]

Acetone Bodies in the Blood.—Accepting 10 mg. total acetone bodies (estimated as acetone) per 100 c.c. of blood as the upper normal limit, it was found that of the twenty-two cases mentioned, fourteen, at one or more observations, gave values above the normal, while eight at all times gave values within the normal limit. The maximum value found was 53 mg., which was reached twenty-four hours after operation. Twenty of the twenty-two cases reached their maximum acetone body content of the blood in the first twenty-four hours. In three of these the maximum was reached one, six and eleven hours after operation, and in two of the three the high value was maintained through the first twenty-four hours. Two cases gave quite normal values during the first twenty-four hours, but by the end of the second twenty-four hours had reached a maximum of 33 and 35 mg. The maximum content in most instances was found near the end of the first twenty-four hours, and the average content at this time was 15.7 mg.

In another group of twenty cases having ether as an anesthetic, there was found twenty-four hours after operation an average content in the blood of 13.4 mg., and in a group of thirty-seven cases having nitrous oxid as an anesthetic there was found twenty-four hours after operation an average of 16.7 mg. The average of seventy-nine cases of the three groups was 15.6 mg., with a maximum value of 61 mg.

Plasma Carbonate.—Accepting 50 vol. per cent. as the lowest normal value, it was found that of the twenty-two cases described, nine cases at all times gave values within the normal limits. Values below 50, at one or more observations, were obtained in thirteen cases, and below 40 in seven cases, the lowest value obtained being 32.4 vol. per cent. Of the thirteen cases giving values below 50 vol. per cent., ten had their minimum value in the first twenty-four hours, seven of these having their minimum value near the end of this period, while three cases had the minimum value at the first observation, one, one and six hours after operation. The remaining three cases had their lowest value at twenty-eight, thirty-four and forty-eight hours after operation.

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Acetone Bodies in the Urine.—In the twenty-two cases described the acetone bodies of the pre-operative urine specimen were normal in amount in all except one case, in which there was but a slight increase. The maximum excretion of total acetone bodies (estimated as acetone) in the first twenty-four hours after operation was 2.36 gm., and in the second twenty-four hours was 5.38 gm., these values being obtained in different cases. The excretion in several patients after operation did not differ from the normal, and in one-third of the cases the amount in the second twenty-four hours was less than that in the first. There was an average excretion of 0.46 gm. in the first twenty-four hours and of 0.9 gm. in the second. The higher acetone values in the second twenty-four hours are the natural result of the higher blood acetone values obtained in the latter part of the first twenty-four hours. Another group of twenty-seven operative cases having ether anesthesia, gave an average acetone body excretion for comparable periods after operation practically identical with that of a group of thirty-six cases having nitrous oxid.

Ammonia Coefficient in the Urine.—After having determined the plasma carbonate, the ammonia coefficient of the urine is relatively of but little value, since the latter when increased is merely indicative of an increase of acids or a need of alkali in the body, while the former may be taken as conclusive evidence of an alkali need and as good presumptive evidence of an acid increase. The ammonia coefficient gives some idea as to the amount of base spared to the body by this means of body defense. In the twenty-two cases of this study there was found in the preoperative specimen an average ammonia coefficient of 7.4 with a maximum of 12. In the first twenty-four hours after operation there was found an average coefficient of 8.6, with a maximum of 16.9, and in the second twenty-four hours was found an average of 9.5 with a maximum of 19.3. The higher coefficient in the second twenty-four hours after operation corresponds to the maximum plasma carbonate reduction in the latter part of the first twenty-four hours.

Comparison of the Increase of Acetone Bodies with the Decrease of Plasma Carbonate.—Roughly, and in a general way, we find in these cases a certain parallelism between the decreased carbonate and the increased acetone bodies of the blood. We find in most instances the largest amount of blood acetone bodies toward the end of the first twenty-four hours, and likewise, in most instances, the lowest carbonate values at about the same time. A brief glance at the following table, however, will show the decided absence of any close association as determined in these cases.

These blood findings are corroborated by the urine examination. In Case 5 is found a total excretion of acetone bodies for forty-eight

hours after operation of 0.144 gm., and the low carbonate is corroborated by finding an ammonia coefficient in the second twenty-four hours after operation of 19.3.

In Cases 5, 6 and 9 there is observed a much reduced plasma carbonate with a practically normal acetone body content of the blood. In the other cases, though the acetone bodies are increased, they are not increased sufficiently to reduce the reserve alkali to the extent indicated, even if increased ammonia production is left out of consideration. In all of these cases the excess of ammonia in the urine is more than sufficient, and in several cases, several times the amount that would be required to neutralize the acetone bodies excreted at the same time.

TABLE SHOWING FINDINGS IN AUTHORS' CASES

Case	Blood Carbonate Vol. Per Cent.	Total Acetone Bodies 100 gm. Blood	Interval in Hours
1	39.2	31.0	
2	52.2	26.0	
	45.6	9.8	24
3	44.9	28.4	
	39.2	22.2	6
	48.3	23.6	27
5	45.4	11.8	
	32.4	12.0	5
	53.2	4.0	20
6	37.6	2.7	
	40.0	3.0	7
	39.8	7.0	8
	52.9	8.2	6
9	45.7	2.3	
	43.8	2.7	4
	50.0	3.5	5
15	33.4	53.0	
	46.3	51.0	9
20	44.0	39.0	
	39.4	37.0	11

It is evident that in these postoperative cases, which were asymptomatic as far as acid intoxication is concerned, there occurs an acid factor other than the acetone bodies, and that this factor is quantitatively important. That the same acid factor may occur in cases showing hyperpnea and other symptoms ascribed to acid intoxication, is shown by observations on a patient operated on for ruptured liver.

which case did not fall into the routine study that was made on the twenty-two cases described. This patient showed in the blood 44.5 mg. total acetone bodies per 100 c.c., and at the same time 24 vol. per cent. plasma carbonate. Such an amount of acetone bodies could not possibly have reduced a normal plasma carbonate to this dangerous level.

As an illustration of an instance in which the acetone bodies alone fully account for the reduction of plasma carbonate, may be cited a case of cyclic vomiting in which was found an acetone body content in the blood of 107 mg. per 100 c.c., associated with a carbonate content of 36.2 vol. per cent. A larger series of postoperative cases might reveal instances in which a much reduced blood carbonate could be largely or wholly accounted for by the amounts of acetone bodies found, but the point we wish to make is that, contrary to much current opinion and our own previous prejudice, there has been shown by this study to be some very important factor in the production of low carbonate content of the blood other than the increased production of acetone bodies. That the margin of safety for the patient would be greater were the acetone bodies not increased there can be no doubt, and the measures now in common use directed against the acetone increase, if shown to be effective, still have their field of usefulness.

The Rôle of Starvation.—That the acetone bodies are increased in starvation is a matter of common knowledge, and that there are other factors than starvation in the acetone production of operative cases seems certain from our observations. Though there is some factor that we may inadequately describe as personal idiosyncrasy in the reaction to starvation, a serious acidosis caused by simple starvation of the duration commonly incident to surgical operation does not seem probable. In seven apparently normal children, subjected to simple fast for forty-eight hours, there was found in the blood at the end of the first twenty-four hours an average of 39.3 mg. total acetone bodies, with a maximum of 72 mg., and at the end of the second twenty-four hours was found an average of 68 mg., with a maximum of 106 mg. None of the children showed any sign of illness. That starvation does not necessarily produce a marked increase of the acetone bodies was shown by a patient who five days after the institution of a therapeutic fast showed 6.6 mg. acetone bodies per 100 c.c. of blood, with a plasma carbonate of 50.5 vol. per cent., and at the end of eight days of fast had 22.6 mg. acetone bodies with a plasma carbonate of 56 vol. per cent. In a study of acetone body formation as a result of fast now being made in this clinic by Veeder and Johnston, several cases have been encountered in which the acetone bodies were but slightly increased, and in all the cases so far studied by them the blood carbonate reduction has not been greater than could be adequately accounted for by

the amount of acetone bodies found, and it may be concluded that starvation itself does not enter into the unknown acid factor described for the operative cases.

SUMMARY

The acetone bodies of the blood were somewhat increased after operation in about two-thirds of the children studied, the maximum amount being found in most instances about twenty-four hours after operation. The plasma carbonate was reduced in about two thirds of the cases, the greatest reduction occurring in most instances about twenty-four hours after operation. When more closely compared there was found to be no close relation between the increase of acetone bodies and the reduction of plasma carbonate. In most instances, especially in those cases in which the plasma carbonate was much reduced, the acetone bodies were entirely inadequate to account for the degree of reduction of plasma carbonate. The undetermined acid factor was apparently of much greater importance than the acetone bodies in the reduction of reserve alkali. The starvation incident to operation seems to play no part in the production of this undetermined factor.

INTUSSUSCEPTION OF THE BOWEL IN AN INFANT

FOLLOWED BY OBSTRUCTION OF THE BOWELS WITH A SECOND INTUSSUSCEPTION WITHIN THREE WEEKS AFTER THE FIRST OPERATION *

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History.—Ann J., born Feb. 18, 1915, was taken ill during the evening of June 14, 1915, with some abdominal distress. The family physician, Dr. S. Peskind, saw the child the following day and, suspecting intussusception, advised the child's immediate removal to the hospital. The child arrived at the East Fifty-Fifth Street Hospital June 15 and was taken to the operating room at 5:30 p. m.

First Operation.—The lower end of the ilium, appendix, cecum, and part of the ascending colon were found telescoped into the transverse colon. When liberated the incarcerated bowel appeared very dark—gangrenous in spots. The age of the child and a pulse scarcely perceptible while under anesthesia precluded any attempts at resection of the devitalized viscus. The appendix, almost black in appearance, was quickly tied off and removed. The wound was closed and the child left the operating room with a very feeble heart action. The operation itself required less than fifteen minutes. At 6:15 p. m. the baby, then in its bed, had a temperature of about 100 F., pulse over 180, respirations between 56 and 60. The child, as soon as she recovered from the anesthetic, was given a few drops of Vichy water every ten or fifteen minutes and was put to the mother's breast for a few minutes at 10 in the evening. The child vomited a few times after the operation. A saline injection was given at 11 in the evening, which was expelled with flatus and was tinged with blood. The following day the temperature went up to 103.2 F., pulse 180 and over. Within forty-eight hours the temperature and pulse reached the normal. The recovery seemed complete within nine days and the little patient was sent home June 24, apparently free from signs of any gastro-intestinal disturbance.

Second Operation.—At 10:15 a. m., July 8, just three weeks after the first operation, the child was brought back to the East Fifty-Fifth Street Hospital with symptoms of acute obstruction of the bowels. Some resistance was felt in the cecal region, also in the middle of the transverse colon. The child looked hopelessly ill. The abdomen was opened and several inches of the ascending colon were found telescoped in the transverse part of the colon. This second intussusception was easily released and the bowel had a normal appearance. At the site of the first intussusception, however, were found the greatest foci of pathologic activity. The cecum and part of the ilium were both matted and bound together by unyielding adhesions. The lumen of the bowel felt as if it were obliterated. The only chance for the restoration of the continuity of the lumen of the bowel was to resort to ileocecostomy, and this was done. The child, not quite 5 months old, bore the operation seemingly without any additional shock. It required just twenty-six minutes to disengage the intussusception, to make the anastomosis, and to close the abdominal wound. Scarcely any gastro-intestinal difficulties followed the second operation, but

* Submitted for publication May 17, 1917.

a double pneumonia developed on the third day and the baby had to fight for its life for nearly two weeks. The temperature often exceeded 105 F. and the pulse rate over 180 per minute. The child remained in the hospital about a month after the second operation and was sent home Aug. 10, 1915. It is now a year and nine months since the child was operated on and at no time since has she evinced any sign of intestinal or pulmonary disturbances.

The interesting points to be drawn from this case are that it is almost impossible to measure with certainty a baby's power of resistance, and at the same time it emphasizes to me the seriousness of the surgeon's position in such cases, when he dares attempt the possibility of saving a human life in spite of apparent hopelessness.

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